THE NEW OMAHA BRIDGE.

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THE NEW OMAHA BRIDGE.

A REPORT

To CHARLES FRANCIS ADAMS, President of the Union Pacific Railway Company,

BY

GEORGE S. MORISON, Chief Engineer of the Omaha Bridge.

SUBJECTS.

APPENDICES.

PLATES.

1889.

New York, November 1, 1888.

Charles Francis Adams, Esq.,

President Union Pacific Railway Company.

Dear Sir: —

I submit the following final report in relation to the reconstruction of the bridge across the Missouri River at Omaha.

Yours truly,

GEO. S. MORISON,

Chief Engineer Omaha Bridge.

THE NEW OMAHA BRIDGE.

I.

PRELIMINARY NARRATIVE.

The original Omaha Bridge was begun in 1869, and opened for traffic in 1872. It was built under the directions of Mr. Theophilus E. Sickels, Chief Engineer. The contract for the entire work was originally let to Mr. L. B. Boomer, of Chicago, but by a subsequent arrangement the foundation work was done under the immediate charge of the Chief Engineer.

As originally built this bridge consisted of eleven spans, of 250 feet each; the approach on the east side being a solid embankment, and that on the west side a cottonwood trestle which was shortly afterwards filled. In 1877 the two easterly spans were blown down; and the eastern span was never restored, its place being supplied by an inexpensive timber trestle. The substructure consisted of eleven iron piers and one stone pier, all of which were founded on rock, the iron piers being numbered from west to east. The eastern iron pier and the stone pier at the west end were buried in the embankments of the approaches. Each pier consisted of two cylinders $8\frac{1}{2}$ feet in diameter, placed $18\frac{1}{2}$ feet between centers, and braced together by cast-iron struts and diagonal ties above low water. The cylinders of Pier XI. (buried in the bank) were of cast iron for the whole height of the pier. The cylinders of the other piers were of cast iron below high water, the sections being 10 feet long, cast in a single piece and bolted together through internal flanges. Above high water the cylinders were of wrought iron, $\frac{1}{16}$ of an inch thick, with heavy cast-iron caps. The lower 12 feet of the cylinders were filled with concrete, which appears to have been tight enough to exclude the water; above this the cylinders were filled with rubble masonry. The cylinders were more or less irregular in position; and in providing for the erection of the superstructure of the new bridge it became necessary to figure very closely to overcome these irregularities.

The original superstructure was for a single track, of the Post pattern, the trusses being 28 feet deep, divided into twenty-two panels, the web being of the triple-intersection system. The trusses were spaced $18\frac{1}{2}$ feet between centers. The top chords were of cast iron, and all other principal members of wrought iron. The new span which replaced one of the spans blown down in 1877 was of wrought iron throughout, of the same depth and width as the other spans, but of the double-system Whipple type, with vertical end posts. The bridge was the most prominent example in America of the Post superstructure and pneumatic cylinder piers.

At the time this bridge was built the regimen of the river in front of Omaha was very uncertain, the tendency being for the channel to move eastward rather than westward. Subsequently a cut-off above the city gave the river a more stable character, and the channel moved to the west. Had the construction of the bridge been deferred ten years the channel would have skirted the bluff on which Omaha is built, the entire bottom-land now occupied by railroad yards and other interests in front of the city would probably have been washed away, and the situation would have become an exceptionally favorable one for the construction of a bridge.

In May, 1885, at your request I visited Omaha and made a careful examination of the old Omaha Bridge. As the result of this examination, on May 23 I made a full report to you, in which I considered certain modifications which it seemed important should be made at all events, and recommended a plan for the reconstruction of the entire bridge as a first-class double-track railroad bridge with independent roadways for travel.

On the 10th of September, 1885, you telegraphed me to take measures for rebuilding the bridge on the plan recommended in my report. On September 18, 1885, you wrote to me that at a meeting of the Executive Committee it was voted to proceed at once with the work of reconstruction, and you instructed me to proceed to reconstruct the Omaha Bridge in the manner recommended in my report of May 23.

On September 19 I appointed Mr. H. W. Parkhurst Assistant Engineer of Foundations, and directed him to proceed at once to Omaha and take charge of the work. Mr. Parkhurst arrived at Omaha on September 22, and made arrangements for beginning the foundation work immediately. The construction of the new Omaha Bridge really dates from this day.

The fact that the work was the reconstruction of an old bridge, over which a heavy train service was to be maintained at all times, made it seem expedient to keep the control of the work as much in the company's own hands as possible. It was therefore determined to do everything on the ground by day's work under the immediate direction of the engineers, except the building of the masonry, which it was thought best to do by contract. The foundations were put in by the company's own men by day's work, and the superstructure was erected in the same manner, the material being manufactured at an Eastern establishment by contract.

On October 13 a contract was closed with Messrs. T. Saulpaugh & Company, for the construction of the masonry.

On the evening of December 11 Mr. Parkhurst met with a serious accident in Omaha near his residence, which incapacitated him from work for several months. On December 15 Mr. George A. Lederle took Mr. Parkhurst's place, and as Resident Engineer continued in immediate charge of the work until the bridge was completed.

The framing of the timber for the caisson for the first pier was begun October 29, and air pressure was put on December 15, the day that Mr. Lederle took charge of the work.

On December 7 invitations were sent to nine prominent bridge builders, inviting proposals for the construction of the superstructure; eight of these parties responded. The proposals were opened on December 29, and the work was awarded to the Union Bridge Company, as the lowest bidder.

The work was continued without interruption from this time forward, the erection of the last span being finished May 14, 1887.

After the first of June, 1887, the difficult part of the work being entirely completed, Mr. Lederle was transferred from Omaha to Portland, Oregon, where he took charge of the bridge across the Willamette River; and Mr. E. Duryea, Jr., was appointed Resident Engineer. The bridge was completed before the connecting tracks were ready on either end, and it was not put in use as a double-track structure until October 1, 1887.

On the 10th of November, 1887, Mr. Duryea and others drove across and returned in a carriage, thus using the carriage-ways for the

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first time. On the same day Mr. Duryea turned the bridge over to Mr. V. G. Bogue, Chief Engineer of the Union Pacific Railway; and my connection with the structure ceased. As a preliminary to this transfer, on the third day of November, 1887, I addressed a letter to Mr. T. J. Potter, showing in detail what remained to be done. This letter may be found in Appendix G.

II.

GENERAL DESCRIPTION.

THE new Omaha Bridge was designed to accommodate both railroad and highway traffic. It is a double-track railroad bridge; the two tracks being placed 12 feet between centers, and the clearance between trusses being 26 feet. The highways are carried on cantilever arms projecting outside the trusses.

The new bridge is really a reconstruction of the old bridge, though very little of the old bridge remains. The same approaches are used, and the location is entirely unchanged, while the dimensions of the old structure fixed the dimensions of the new structure.

The old bridge was 2,750 feet long, but for several years little or no water had flowed through the four easterly spans. A clear width of 1,000 feet affords ample water-way on this section of the Missouri. In many places where the channel has remained stable for a long series of years, the river has reduced its width between high-water banks to less than this. It was farther decided to limit the water to the space between Piers I. and VI., or to a width of 1,250 feet, the additional 250 feet more than balancing the obstruction offered by the old piers and the piles of riprap around them. The length of the new bridge is, however, 1,750 feet; the 250 feet west of Pier I. and that between Piers VI. and VII. being occupied by an iron structure, though the flood water is entirely excluded therefrom.

The cylinders of the old piers are $8\frac{1}{2}$ feet in diameter, having a cross-section of about 57 square feet; the weight of the superstructure being carried directly on the masonry filling and not borne by the iron shell. The maximum weight of superstructure and moving load which each of these cylinders was required to bear was at least 300 tons, producing a pressure of about 75 pounds per square inch on top of the cylinders, and of over 200 pounds at the base. These pressures were considered as large as it was wise to use on this kind of work.

The old piers had been protected by heavy piles of riprap around them, which made it seem expedient to build the new piers as far from the old piers as possible, where the obstructions to be encountered would be a minimum. This fixed the location of the new piers half-way between the old piers. With the possible water-way of the new bridge limited to the space between Piers I. and VI., and with the location of the new piers fixed midway between the location of the old piers, two arrangements were possible: three new piers and two spans of 500 feet each, or five new piers and four spans of 250 feet each. If you had been building an ordinary single-track railroad bridge the former arrangement would have been preferable; but for the heavy double-track structure which has been erected, the latter arrangement was found a little more economical, besides giving very much better facilities for handling the work independently of stages of water, the short spans of less than 125 feet between the old and new piers making it possible to raise without danger at all times.

The structure as now built extends from the old masonry pier to Pier VI., — a distance of 1,750 feet. The easterly and westerly spans of this length were subdivided by building two new piers. As these piers are outside the limits within which the flow of the river is confined, it was not thought necessary to go to the expense of putting in deep foundations, and they are founded on concrete at shallow depths. The bridge, therefore, consists of four through spans measuring 1,000 feet between centers of piers, and at each end three deck spans measuring 375 feet between centers of piers, — making the total length, as already stated, 1,750 feet.

The east approach is the old approach, which your company have widened for a double track; and the embankment when completed — which I strongly advise be done as soon as possible — will extend to and surround the old Pier VII. The west approach is the old approach widened. Both approaches are on the same tangent as the bridge, and the grade is level from the west end of the west approach to Pier VII., — the east end of the east approach, — from which point a uniform grade of $\frac{6}{10}$ of one per cent descends towards Council Bluffs.

The river is now in quite a stable condition, the only danger coming from the erosion of the east bank, three or four miles above, which tends gradually to throw the bend above the city further down stream. The vested interests in Council Bluffs and elsewhere will, however, probably prevent this erosion continuing to a dangerous extent. The west shore is thoroughly protected from the smelting works to the bridge line. The general direction of this shore makes an angle of about 110° with the bridge line. It would be very desirable to have this shore line forced forward until it be at right angles with the bridge. The expense of doing this would be pretty large, but it would reclaim from the river an amount of very valuable land worth several times the cost of the work. I fear, however, that this contemplated scheme has since been blocked by the construction of the highway bridge at the foot of Douglas Street.

The rectification of the river here is a matter of large importance, not only as regards the bridge, but as regards many other interests. As at other places on the Missouri, the bottom-land slopes lightly away from the river. At the place where the river has been cutting above Omaha, the bottom-land is lower than it is at the bridge site, and the surface of the water is a few feet higher. The danger of overflow to the lower portion of Council Bluffs comes from this place, as a rise of water which would be perfectly harmless at the bridge line would make an overflow three or four feet deep at this place. A location was made for a line of levee from Pier VI. to the east bluff above Council Bluffs. This levee is the only sure way of protecting the lower portion of Council Bluffs from the overflow, and it would seem that the united interests of the railroad and the property owners ought to build it.

During the conduct of the work all levels were referred to the datum used during the construction of the old bridge, and this datum was the assumed low water, which, however, is considerably below any low water which has actually been observed, and six feet lower than the low water recently established by the Missouri River Commission. To avoid the use of negatives, this datum was called 100. Therefore, in the elevations used in this report, 100 corresponds to 0 in the published reports of stages of water, that zero being according to the levels of the Missouri River Commission, 545.61 feet above the St. Louis city directrix, which is 413.05 feet above mean tide in the Gulf of Mexico. To refer the levels of this report to tide-water, it will be necessary to add 858.66.

III.

SUBSTRUCTURE.

THE five piers are designated by letters, Pier A being the most easterly. This designation was adopted to avoid confusion with the old piers, which were numbered; the numbering being from west to east.

The five piers are founded on pneumatic caissons of the following dimensions: —

Pier A,	65 feet long,	25 feet wide, and	18 feet high.
Pier B,	65 " "	25 " "	18 " "
Pier C,	66 " "	26 " "	18 " "
Pier D,	65 " "	25 " "	18 " "
Pier E,	65 " "	25 " "	18 " "

The foundations were put in by the company's men under the direction of the Engineer. The masonry was built by contract by the firm of T. Saulpaugh & Company.

The caisson for Pier A was built on the dry sand-bar on the east side of the river. The other four caissons were built in position on pile false-work, and lowered by long screws to the bottom of the river.

The pneumatic machinery was set up on the east side of the river, south of the old Pier VI. It consisted of two No. 4 Clayton Duplex Compressors, the power being supplied by three old locomotive boilers. A Worthington Packed Plunger, Duplex Pump, with 18½-inch steam cylinder and 10¼-inch water plunger, supplied the power for the sand pump excavators. These sand pumps were of a special pattern designed by me and illustrated on Plate 7.

A temporary pile bridge was built each year from the east bank of the river fifty feet north of the bridge line, extending during the first season as far as Pier C, and during the second season completely across the river. A service track was laid on this bridge, and the Worthington pump was then set up on this bridge, steam being supplied from the boilers on the shore. The air for the caissons was led from the pumps to Piers C and D by a pipe laid on the floor of the old bridge; this arrangement being adopted so that the air supply could be kept up in case any injury occurred to the temporary pile bridge. During the second season the Worthington pump was put on a barge, and steam supplied by two 60 H. P. portable boilers erected on this barge. After the completion of foundation D the pneumatic machinery was moved from the east sand-bar and set up on the west side of the river.

The caissons were built of Oregon fir, with cutting edges of iron, strongly bolted together, and filled with Portland cement concrete. The caisson for Pier A is surmounted by 38 feet of crib-work, that for Pier B by 13 feet of crib-work, and that for Pier C by 6 feet of crib-work; the crib-work being filled with concrete similar to that used in the caissons. The masonry of Piers D and E starts from the top of the caisson. The framing of the caisson for Pier A was begun October 29, 1885, the erection of the caisson November 6, and air pressure was put on December 15. The laying of masonry began January 11, 1886, and the caisson reached bed-rock at elevation 35.72 on January 31. The sealing of the working chamber was begun February 1, and completed February 8. The masonry was finished April 22, 1886.

The framing of the caisson for Pier B began November 27, 1885, the construction of the staging December 2, the erection of the caisson January 5, 1886, and the lowering with screws January 30. On February 5 the caisson rested on the bed of the river, and air pressure was put on February 6. The laying of masonry began February 11, and the caisson reached the rock at elevation 28.62 on March 7. The concrete filling of the working chamber was begun March 9, and finished March 12. The masonry for this pier was completed June 12, 1886.

The framing of the caisson for Pier C began June 28, 1886, the construction of the staging July 31, the erection of the caisson August 18, and the lowering with screws September 15. Air pressure was put on September 17, and on the same day the caisson rested on the bed of the river. The laying of masonry began September 23, and the caisson reached bed-rock at elevation 30.07 on October 20. The concrete filling of the working chamber was begun October 24, and finished October 30. The masonry for this pier was completed December 18, 1886.

After the completion of the foundation of Pier C, it was thought wise to discontinue the work until after the flood season of 1886.

The construction of the staging for Pier D was begun September 14, 1886, the framing of the caisson September 15, the erection of the caisson September 23, and the lowering with screws October 27. Air pressure was put on November 3, and on November 4 the caisson rested on the bed of the river. The laying of masonry began November 4, and the caisson reached bed-rock at elevation 40.80 on December 3. The concrete filling of the working chamber was begun December 4, and finished December 7. The masonry for this pier was completed March 8, 1887.

The river closed by ice unusually early, — on November 18, 1886; but it was not thought safe to begin work on the construction of Pier E until the season was so far advanced that there was thought to be no danger of this ice moving. In the intervening time the pneumatic machinery was moved from the east to the west side of the river.

The construction of the staging for Pier E was begun October 19, 1886, and the framing of the caisson was begun on the same day. The erection of the caisson was begun on November 28, and the lowering with screws began January 5, 1887. Air pressure was put on January 9, and on January 10 the caisson rested on the bed of the river. The laying of masonry began January 12, and the caisson reached bed-rock at elevation 46.43 on February 17. The concrete filling of the working chamber was begun February 19, and finished February 22. The masonry for this pier was completed April 7, 1887.

The full details of the five piers, the caissons, the air-locks, and the appliances used in connection therewith, are given on Plates 2, 3, 4, 5, 6, 7, 8, and 9. The rate of progress in sinking is illustrated graphically on Plate 10. Full records of the progress in detail of sinking these foundations were kept, and are given in Appendix C. The detailed cost is given in Appendix D.

The concrete used was manufactured in a mixer consisting of a 9-inch spiral conveyor with teeth arranged between the flights, and running in a wrought-iron trough. The sand, cement, and water were mixed in this mixer, and the stone was put in after depositing the concrete mortar in position, the stones being thrown in by hand and the whole mass thoroughly rammed. Inside of the working chamber no stone was used. The proportions of sand to cement varied from two to four parts of sand to one of cement, the cement being Portland cement except in some unimportant instances.

The cost of the five foundations is shown in detail in the following table; this cost including all concrete and other material below the masonry: —

	Cost, excluding Freight Charges.	Freight Charges.	Cost, including Freight Charges.			
FOUNDATION A:						
CAISSON —						
Materials	$2,882.79	$1,175.43	$4,058.22			
Labor	3,150.16	—	3,150.16	$7,208.38		
CONCRETE FILLING —						
Materials	4,143.62	733.46	4,877.08			
Labor	1,673.87	—	1,673.87	6,550.95	$13,759.33	
CRIB —						
Materials	1,643.25	1,315.47	2,958.72			
Labor	1,774.86	—	1,774.86	4,733.58		
CONCRETE FILLING —						
Materials	8,669.88	1,771.46	10,441.34			
Labor	3,005.23	—	3,005.23	13,446.57	18,180.15	
CUTTING EDGE, AIR-LOCK, SHAFTS, ETC.	2,374.34	105.95	2,480.29	—	2,480.29	
SINKING —						
Materials	2,305.29	—	2,305.29			
Labor	7,785.08	—	7,785.08	—	10,090.37	
ERECTION AND REMOVAL OF MACHINERY	1,027.60	—	1,027.60	—	1,027.60	
	40,435.97	5,101.77				$45,537.74
FOUNDATION B:						
CAISSON —						
Materials	3,032.09	1,131.49	4,163.58			
Labor	4,023.47	—	4,023.49	8,187.07		
FALSE-WORK —						
Materials	482.62	267.93	750.55			
Labor	1,231.22	—	1,231.22	1,981.77		
CONCRETE FILLING —						
Materials	3,809.83	743.12	4,552.95			
Labor	1,626.76	—	1,626.76	6,179.71	16,348.53	
CRIB —						
Materials	625.12	570.10	1,195.22			
Labor	942.57	—	942.57	2,137.79		
CONCRETE FILLING —						
Materials	2,849.89	577.48	3,427.37			
Labor	1,207.02	—	1,207.02	4,634.39	6,772.18	
CUTTING EDGE, AIR-LOCK, SHAFTS, ETC.	2,400.09	105.96	2,506.05	—	2,506.05	
SINKING —						
Materials	1,701.14	—	1,701.14			
Labor	5,043.06	—	5,043.06	—	6,744.20	
ERECTION AND REMOVAL OF MACHINERY	1,212.10	—	1,212.10	—	1,212.10	
	30,186.98	3,396.08				33,583.06
FOUNDATION C:						
CAISSON —						
Materials	$3,140.59	$1,512.40	$4,652.99			
Labor	3,531.59	—	3,531.59	$8,184.58		
FALSE-WORK —						
Materials	838.49	271.16	1,109.65			
Labor	333.14	—	333.14	1,442.79		
CONCRETE FILLING —						
Materials	4,562.11	902.07	5,464.18			
Labor	1,733.26	—	1,733.26	7,197.44	$16,824.81	
CRIB —						
Materials	299.70	323.94	623.64			
Labor	361.39	—	361.39	985.03		
CONCRETE FILLING —						
Materials	1,307.73	507.16	1,814.89			
Labor	231.64	—	231.64	2,046.53	3,031.56	
CUTTING EDGE, AIR-LOCK, SHAFTS, ETC.	2,298.49	157.90	2,456.39	—	2,456.39	
SINKING —						
Materials	1,408.61	—	1,408.61			
Labor	6,304.54	—	6,304.54	—	7,713.15	
ERECTION AND REMOVAL OF MACHINERY	688.58	—	688.58	—	688.58	
	27,039.86	3,674.63				$30,714.49
FOUNDATION D:						
CAISSON —						
Materials	2,994.54	1,288.11	4,282.65			
Labor	3,910.50	—	3,910.50	8,193.15		
FALSE-WORK —						
Materials	583.13	—	583.13			
Labor	499.53	—	499.53	1,087.66		
CONCRETE FILLING —						
Materials	4,513.45	918.57	5,432.02			
Labor	1,525.60	—	1,525.60	6,957.62	16,233.43	
CUTTING EDGE, AIR-LOCK, SHAFTS, ETC.	2,305.73	163.32	2,469.05	—	2,469.05	
SINKING —						
Materials	1,146.42	—	1,146.42			
Labor	4,620.30	—	4,620.30	—	5,766.72	
ERECTION AND REMOVAL OF MACHINERY	776.19	—	776.19	—	776.19	
	22,875.39	2,370.00				25,245.39
FOUNDATION E:						
CAISSON —						
Materials	2,922.28	1,439.85	4,362.13			
Labor	4,232.90	—	4,232.90	8,595.03		
FALSE-WORK —						
Materials	654.82	—	654.82			
Labor	553.49	—	553.49	1,208.31		
CONCRETE FILLING —						
Materials	3,028.02	1,098.72	4,126.74			
Labor	1,253.90	—	1,253.90	5,380.64	15,183.98	
CUTTING EDGE, AIR-LOCK, SHAFTS, ETC.	2,505.45	161.46	2,666.91	—	2,666.91	
SINKING —						
Materials	1,872.93	—	1,872.93			
Labor	6,442.57	—	6,442.57	—	8,315.50	
ERECTION AND REMOVAL OF MACHINERY	1,924.36	—	1,924.36	—	1,924.36	
	25,390.72	2,700.03				28,090.75
GRAND TOTAL COST OF FIVE MAIN FOUNDATIONS	$145,928.92	$17,242.51				$163,171.43

The greater part of the stone used for the masonry is limestone from Mankato, Minn.; but the entire dimension work, wherever exposed to frost, is of granite quarried near St. Cloud, Minn. The granite begins at the following elevations in the several piers: —

Pier.	Up-Stream Ends.	Balance of Pier.
A	98.15	108.57
B	95.61	99.69
C	93.82	97.90
D	94.32	98.40
E	92.69	96.77

The high level at which the granite begins in Pier A was due to the fact that bed-rock was found at a higher level than the records of the old bridge had led us to expect. Under ordinary circumstances the limestone will always be buried in the ground; but under certain conditions it may be exposed, and I now regret that two courses more of granite were not put on.

The cost of the masonry in detail is shown in the following table: —

	PIER A.			
Estimate —				
Masonry laid, $16.50 per cu. yd.	cu. yds. 1,368.62	—	$22,582.23	—
Granite in Masonry, $4.00 per cu. yd. extra	643.55	—	2,574.20	—
				$25,156.43
Labor — Extra Cutting	—	—	—	53.25
Freight Charges on Granite	643.55	—	4,520.29	—
Freight Charges on Limestone	725.07	$3,056.89	—	—
Mileage on Limestone	—	362.53	—	—
			3,419.42	
Mileage on Small Stone	—	—	154.30	—
				8,094.01
Work-Train Service	—	—	—	600.00
Portland Cement, $2.75 per bbl.	bbls. 569	1,564.75	—	—
Freight Charges do.	—	347.09	—	—
			1,911.84	
Milwaukee Cement, $0.70 per bbl.	67	46.90	—	—
Freight Charges do.	—	27.47	—	—
			74.37	
				1,986.21
Kansas Cement	—	—	—	—
Freight Charges do.	—	—	—	—
Total	—	—	—	$35,889.90
Cost per Yard of Masonry	—	-	—	26.22
Average Cost per Yard of Masonry	—	—	—	—

	PIER B.			
Estimate —				
Masonry laid, $16.50 per cu. yd.	cu. yds. 2,217.23	—	$36,584.29	—
Granite in Masonry, $4.00 per cu. yd. extra	740.54	—	2,962.16	—
				$39,546.45
Labor — Extra Cutting	—	—	—	—
Freight Charges on Granite	740.54	—	5,201.55	—
Freight Charges on Limestone	1,476.69	$6,225.72	—	—
Mileage on Limestone	—	738.39	—	—
			6,964.11	
Mileage on Small Stone	—	—	249.99	—
				12,415.65
Work-Train Service	—	—	—	1,013.78
Portland Cement, $2.75 per bbl.	bbls. 936	2,574.00	—	—
Freight Charges do.	—	570.96	—	—
			3,144.96	
Milwaukee Cement, $0.70 per bbl.	233	163.10	—	—
Freight Charges do.	—	95.53	—	—
			258.63	
Kansas Cement	11	6.05		
Freight Charges do.	—	4.40		
			10.45	
				3,414.04
Total	—	—	—	$56,389.92
Cost per Yard of Masonry	—	—	—	25.43
Average Cost per Yard of Masonry	—	—	—	—

	PIER C.			
Estimate —				
Masonry laid, $16.50 per cu. yd.	cu. yds. 2,557.86	—	$42,204.69	—
Granite in Masonry, $4.00 per cu. yd. extra	762.01	—	3,048.04	—
				$45,252.73
Labor — Extra Cutting	—	—	—	—
Freight Charges on Granite	762.01	—	5,352.35	—
Freight Charges on Limestone	1,795.85	$7,571.30	—	—
Mileage on Limestone	—	897.92	—	—
			8,469.22	
Mileage on Small Stone	—	—	288.40	—
				14,109.97
Work-Train Service	—	—	—	1,221.35
Portland Cement, $2.75 per bbl.	bbls. 580	1,595.00	—	—
Freight Charges do.	—	353.80	—	—
			1,948.80	
Milwaukee Cement, $0.70 per bbl.	823	617.25	—	—
Freight Charges do.	—	296.28	—	—
			913.53	
				2,862.33
Kansas Cement				
Freight Charges do.				
Total	—	—	—	$63,446.38
Cost per Yard of Masonry	—	—	—	24.84
Average Cost per Yard of Masonry	—	—	—	—

	PIER D.			
Estimate —				
Masonry laid, $16.50 per cu. yd.	cu. yds. 2,232 31	—	$36,833.11	—
Granite in Masonry, $4.00 per cu. yd. extra	759.02	—	3,036.08	—
				$39,869.19
Labor — Extra Cutting	—	—	—	17.50
Freight Charges on Granite	759.02	-	5,331.35	—
Freight Charges on Limestone	1,473.29	$6,211.39	—	—
Mileage on Limestone	—	736.65	—	—
			6,948.04	
Mileage on Small Stone	—	—	251.68	—
				12,531.07
Work-Train Service	—	—	—	1,013.78
Portland Cement, $2.75 per bbl.	bbls. 548	1,507.00	—	—
Freight Charges do.	—	334.28	—	—
			1,841.28	
Milwaukee Cement, $0.70 per bbl.	548	383.60	—	—
Freight Charges do.	—	224.68	—	—
			608.28	
				2,449.56
Kansas Cement				
Freight Charges do.				
Total	—	—	—	$55,881.10
Cost per Yard of Masonry	—	—	—	25.03
Average Cost per Yard of Masonry	—	—	—	—

	PIER E.			
Estimate —				
Masonry laid, $16.50 per cu. yd.	cu. yds. 2,039.98	—	$33,659.67	
Granite in Masonry, $4.00 per cu. yd. extra	789.33	—	3,157 32	
				$36,816.99
Labor — Extra Cutting	—	—	—	17.50
Freight Charges on Granite	789.33	—	5,544.25	
Freight Charges on Limestone	1,250 65	$5,272.73		
Mileage on Limestone	—	625 33		
			5,898.06	
Mileage on Small Stone	—	—	230.00	
				11,672.31
Work-Train Service	—	—	—	1,314.13
Portland Cement, $2.75 per bbl.	bbls. 577	1,586.75		
Freight Charges do.	—	351 97		
			1,938.72	
Milwaukee Cement, $0.70 per bbl.	139	97.30		
Freight Charges do.	—	56.99		
			154.29	
				2,093.01
Kansas Cement				
Freight Charges do.				
Total	—	—	—	$51,913.94
Cost per Yard of Masonry	—	—	-	25 45
Average Cost per Yard of Masonry	—	—	—	25 30

The total cost of the five principal piers was as follows: -

	Cost, excluding Freight.			Freight Charges.			Cost including Freight.			Gross Volume.	Cost per Cubic Ft.	Cu. Ft. Sunk (Area base × feet sunk.)	Cost per Cubic Ft.	Vertical Feet Sunk.	Cost per Vertical Ft.
										Cubic Feet.	Cents.		Cents.		
FOUNDATION A:															
Caisson and Filling, including Cutting Edge, etc.	$14,224.78			$2,014.84	—		$16,239.62		—	28,865	56.3				
Crib and Filling	15,093.22			3,086.93			18,180.15		—	51,340	35.4				
Sinking Caisson	10,090.37 }						} 11,117.97			—	—	122,655	9.1	75.48	$147.29
Erection and Removal of Machinery	1,027.60 }	—	—		—	—									
		$40,435.97			$5,101.77			$45,537.74							
FOUNDATION B:															
Caisson and Filling, including False Work, etc.	16,606.08	—		2,248.50		—	18,854.58			28,520	66.1				
Crib and Filling	5,624.60		—	1,147.58		—	6,772.18			17,892	37.8				
Sinking Caisson	6,744.20 }						} 7,956.30		—		—	134,274	5.9	82.63	96.29
Erection and Removal of Machinery	1,212.10 }				—										
		30,186.98			3,396.08			33,583.06							
FOUNDATION C:															
Caisson and Filling, including False Work, etc.	16,437.67			2,843.53			19,281.20		—	29,790	64.7				
Crib and Filling	2,200.46			831.10		—	3,031.56	—		9,428	32.2				
Sinking Caisson	7,713.15 }						} 8,401.73	—			—	137,008	6.1	81.07	103.63
Erection and Removal of Machinery	688.58 }		—												
		27,039.86			3,674.63			30,714.49							
FOUNDATION D:															
Caisson and Filling, including False Work, etc.	16,332.48	—		2,370.00		—	18,702.48			29,304	63.8				
Sinking Caisson	5,766.72 }			—			} 6,542.91		—			113,084	5.8	69.59	94.02
Erection and Removal of Machinery	776.19 }														
		22,875.39			2,370.00			25,245.39							
FOUNDATION E:															
Caisson and Filling, including False Work, etc.	15,150.86	—		2,700.03		—	17,850.89			27,624	64.6				
Sinking Caisson	8,315.50 }			—	—		} 10,239.86		—		—	99,310	10.3	63.66	160.86
Erection and Removal of Machinery	1,924.36 }														
		25,390.72			2,700.03			28,090.75							
TOTAL COST OF FOUNDATIONS	—		$145,928.92	—		$17,242.51	—		$163,171.43				Mean 7.3		Mean. 118.82
										Cubic Yards.	Per Cu. Yd.				
MASONRY, PIER A	—	32,095.93			3,793.98	—		35,889.91		1,368.62	$26.22				
" " B	—	48,754.92	—		7,635.00	—	—	56,389.92		2,217.23	25.43				
" " C	—	54,327.08	—		9,119.30	—	—	63,446.38	—	2,557.86	24.84				
" " D		48,374.10	—	—	7,507.00			55,881.10	—	2,232.31	25.03				
" " E		45,606.92			6,307.02	—		51,913.94		2,039.38	25.45				
TOTAL COST OF MASONRY	—		229,158.95			34,362.30			263,521.25		Average. 25.30				
GRAND TOTAL OF FIVE PIERS			$375,087.87	—		$51,604.81		—	$426,692.68						

On the east side of the river the old Piers VI. and VII. were cut down, the cast-iron caps replaced, and the piers adapted to carry the ends of the deck spans. On each side of the river a new pier was constructed, with a concrete base 20 feet by 38 feet 6 inches, supporting two iron cylinders filled with concrete and formed of parts of the old bridge; the cylinders on the west side have shells of wrought iron; those on the east side of cast iron. These approach piers are shown on Plate 12.

The stones of the old masonry pier at the west end of the old bridge were found to be badly injured by frost. The exposed portion of this pier was removed and replaced by first-class work of Mankato stone. Back of this pier a retainer wall was built of Mankato stone, with a concrete foundation to hold the end of the embankment, which the design of the new bridge made much wider than the old embankment. This retainer wall was kept entirely independent of the pier, so that settlement would not disturb the pier; it settled several inches, and the masonry was badly cracked at the center, but otherwise it is still in good order.

The amount of masonry and concrete in the entire bridge is as follows:—

	Masonry, Cubic Yards.	Concrete, Cubic Yards.	Total.
Pier A	1,368.62	1,770.2	3,138.8
Pier B	2,217.23	1,042.0	3,259.2
Pier C	2,557.86	888.0	3,445.9
Pier D	2,232.31	671.0	2,903.3
Pier F	2,039.98	558.0	2,598.0
East Approach Pier		236.0	236.0
West Approach Pier	—	157.2	157.2
West Approach Retaining Wall	333.43	93.6	427.0
West Abutment	77.51		77.5
Total, Cubic Yards	10,826.94	5,416.0	16,242.9

The total cost of the substructure was as follows:—

Five Piers	$426,692.68
East Approach Pier	3,308.34
West Approach Pier	1,736.92
West Abutment and Retaining Wall	9,077.69
Total Substructure	$440,815.63

The cutting down of old Piers I., VI, and VII. was charged to Removal of Old Works.

IV.

SUPERSTRUCTURE.

The superstructure consists of four through spans and six deck spans,—three on each end. Each through span is 246 feet 2½ inches long between centers of end pins, and each deck span 120 feet 7¾ inches. Expansion is provided for in the through spans by rollers placed on Piers A, C, and E. Expansion is provided for in four of the deck spans by supporting one end on rocking bents which rest on the new approach piers. These bents rock on pins in wrought-iron bolsters resting on the cast-iron caps of the new piers, and secured by long bolts extending into the concrete below; these bolts being of sufficient length to allow of lifting the bolsters in case of a settlement of the piers.[1] In the other two deck spans expansion is provided for by rollers placed on Piers A and E. The entire structure is built for a double track with a carriage-way and footway on each side. The railroad tracks are 12 feet between centers; the carriage-ways 7 feet wide between wheel-guards; the carriage and foot ways 12 feet 1 inch between centers of railings; and the entire floor 53 feet 8 inches over all.

On the seventh day of December, 1885, a circular was addressed to prominent bridge builders, inviting proposals for the construction of the superstructure. On the twenty-ninth day of December the work was awarded to the Union Bridge Company, as the lowest bidder.

The trusses of the through span are divided into eleven panels, of 22 feet 4⅝ inches each, and are of the double-system Whipple type; the trusses being 40 feet deep and placed 28 feet 6 inches between centers. The top chord, end posts, the eye-bars of the bottom chord, and the heavier portion of the main ties, the bolsters, rollers, bearing plates, and pins are of steel. All other parts are of wrought iron, excepting the heavy wall plates resting on the masonry, the washers, and ornamental work, which are of cast iron. The details of these spans are given on Plates 15, 16, 17, 18, and 19.

[1] In the case of the East Approach Pier this was done during construction, the bents and bolsters being raised and thick cast-iron plates put under the wrought-iron bolsters.

Each deck span is divided into five panels, of 24 feet 1½ inches each, the trusses being of the single-system Whipple type without end posts, 18 feet deep and placed 18 feet 6 inches between centers; the width being fixed by the distance between the centers of the columns of the old piers. The deck spans are entirely of wrought iron, excepting the pins, rollers, and bearing plates, which are of steel, and the wall plate pedestals, which are of cast iron. The details of these plans are given on Plates 20, 21, and 22.

The trusses were not proportioned to carry any particular class of locomotives or cars now in use, but the moving load on both roadways and railroad was taken at 8,000 pounds per lineal foot of bridge; and in calculating the effects of a moving load the portion of the strain on each member in excess of the strain which would have been produced by a uniform load of equal intensity was taken on a basis of 10,000 pounds per foot. In the through spans the dead load was taken at 5,000 pounds per lineal foot; the total load was therefore 13,000 pounds per foot; and the calculations gave the same aggregate results, except in the counters, that would have been obtained if the moving load everywhere had been considered as 10,000 pounds per lineal foot and the dead load 3,000 pounds. In the deck span the dead load was taken at 4,000 pounds per foot. The floor system is proportioned for a total load of 6,000 pounds per lineal foot of track throughout. The top lateral system is designed to resist a wind pressure of 300 pounds per lineal foot, and the bottom lateral system 500 pounds per lineal foot. The strains are given on Plate 23.

The steel compression members in the top chord and end posts are made as nearly as possible of a balanced section, the metal in the top cover-plate being practically the same as in the two balance plates below and the lacing. The compression strain on these members was limited to 15,000 pounds per square inch of net section; the net section being obtained by deducting from the gross section the portion of the cover-plate which was in excess of the balance plates, or supposed to be equivalent to the lacing.

The maximum tensile strain allowed in the bottom chord was limited to 14,000 pounds per square inch, and somewhat less in the web members. The maximum strain on iron was limited to 10,000 pounds per square inch, and to 8,000 pounds on extreme fibers of riveted girders.

The weights of iron and steel in the through spans are as follows:

	Four Spans		Average per Span.
	lbs.	lbs.	lbs.
Steel	—	1,540,126	385,031
Wrought Iron in Trusses	961,494		
" " Railroad Floor	955,114		
" Highway Floor	329,596		
Total Wrought Iron		2,246,204	561,551
Cast Iron	—	108,160	27,040
Total	—	3,894,490	973,622

The weights of iron and steel in the deck spans are as follows:

	Six Spans.		Average per Span.
	lbs.	lbs.	lbs.
Steel		30,226	5,038
Wrought Iron in Trusses	972,426		
" " Railroad Floor	624,195		
" " Highway Floor	167,869		
Total Wrought Iron		1,764,490	294,081
Cast Iron	—	44,970	7,495
Total	—	1,839,686	306,614
Four Supporting Bents	—	118,650	
Total	—	1,958,336	

The specifications under which the superstructure was manufactured are given in Appendix E. An attempt was made to get steel made by the Clapp-Griffiths process, but the results were entirely unsatisfactory, only 55 very small charges being accepted. The full number of accepted blows of open-hearth steel was 135, which were made by the following parties: —

Pittsburg Steel Casting Co., Pittsburg, Pa.	72 blows.
Carnegie Bros. & Co. "	22 "
Pennsylvania Steel Co., Steelton, Pa.	41 "

The eye-bar steel was all made at Steelton.

The work was all manufactured by the Union Bridge Company, at their shops in Buffalo, N. Y. Eighteen full-sized eye-bars were tested to destruction, the tests being made in the large testing machine belonging to the Union Bridge Company, at Athens, Pa. The records of these tests are given in Appendix F. This machine being a hydraulic machine, with no weighing apparatus excepting the gauges, cannot be relied upon absolutely for determinations of elastic limit or breaking strain; but the other qualities, which are the only ones insisted on in the specifications, are exact.

The necessity of removing the old bridge and maintaining traffic during the reconstruction made it necessary to adopt a special plan for erection. The deck spans were erected in a simple manner on false-work, and were then made use of as a staging for the removal of the old spans.

In the erection of the through spans advantage was taken of the small distance between the masonry piers and the old iron piers. The first through span erected was that reaching from Pier A to Pier B. An iron harness was placed on old Pier V. and a similar harness on old Pier IV. Four lines of combination trusses were then erected, supported on the masonry piers and on the harnesses, the bottom chord bars of the old bridge being used in these combination trusses; the two inside trusses carried the traffic during erection and the two outside trusses the new work. This arrangement of four trusses was adopted as an extra precaution in case of accident, it being thought that if one truss were destroyed by an accident the other three would remain in position. Fortunately no such accident occurred. The harness and combination spans are shown on Plate 24.

The old trusses were removed by a traveler without the use of upper false-work, and the new trusses were erected in the same manner.

The dates at which the several trusses were erected is shown in the following table: —

	First Iron Placed.	Span Swung.
First East Deck Span	May 18, 1886.	May 31, 1886.
Second " "	" 26, "	June 2, "
Third " "	" 28, "	" 3, "
Through Span A–B	Oct. 2, "	Oct. 9, "
" " B–C	Jan. 28, 1887.	Feb. 14, 1887.
" " C–D	March 30, "	April 7, "
" " D–E	May 9, "	May 14, "
First West Deck Span	June 16, 1886.	June 19, 1886.
Second " "	" 17, "	" 22, "
Third " "	April 19, 1887.	April 24, 1887.

The railroad floor system is shown on Plate 19. It consists of 8 by 8-inch ties, 20 to the panel in the intermediate panels of the through spans, and 22 to the panel in the deck spans and the end panels of the through spans, resting on iron stringers 6 feet between centers. Inside the rails are placed two lines of 5 by 4 by $\frac{5}{8}$-inch angle iron, bolted to every tie by one-inch bolts and laid to an outside gauge of 3 feet 8 inches.

The highway floor is of timber, the wooden stringers being sustained by short floor beams midway between the panel points, these being supported by the light lattice trusses which constitute the railings. The wearing plank of the floor is of 2-inch oak put on diagonally, and the footway is separated from the carriage-way by a gas-pipe railing.

The running of trains was never interrupted for more than two hours at any one time during the entire erection. The double track was first used on October 1, 1887.

At your request symbolic figures were placed at each end of the superstructure. That at the east end is a colossal bronze buffalo head, which was modeled by Captain Edward Kemeys, of Perth Amboy, N. J., and cast by Mr. Etienne Favy, of New York City, this symbol being understood to represent the wildness of the plains which the travelers are approaching. The device at the west end is a bronze bas-relief showing a plow, anchor, and steam hammer, as symbolic of the agriculture, commerce, and manufactures of the East.

The total cost of the superstructure is shown in the following table: —

MAIN SPANS.			
Iron, Steel, and Ornamental Work	$132,193.16		
Freight Charges on same from Chicago	5,586.89		
		$137,780.05	
Labor, — Handling Iron in Yard .	—	3,220.22	
Erection of Spans	—	14,105.44	
Erection and Removal, Engines and Derricks .	—	599.98	
Switching Charges	—	2,344.91	
Coal	—	433.90	
Traveler, — Material and Labor .	—	679.34	
Harness, " " .	—	1,198.64	
False-Work, " " . .	—	3,895.33	
Combination Spans, Framing, Erection and Removal, and Diagonal Bars . .	—	7,473.13	
Miscellaneous Material, — Rope, Iron, Steel, Cement, Oil, Waste, etc . . .	—	1,034.07	
Total Main Spans . .			$172,765.01
APPROACH SPANS.			
Iron and Steel	62,498.85		
Freight Charges on same from Chicago	2,676.30		
		65,175.15	
Labor, — Handling Iron in Yard	—	526.64	
Erection of Spans	—	6,605.93	
Switching Charges	—	740.13	
Coal	—	39.60	
False-Work, — Labor and Materials .	—	3,315.40	
Total Approach Spans . . .	—		76,402.85
RAILROAD FLOOR.			
Materials . . .		9,898.04	
Labor	—	2,655.11	
Total Railroad Floor	—		12,553.15
ROADWAY FLOOR.			
Materials	—	15,534.80	
Labor	—	5,516.15	
Switching	—	1,270.14	
Total Roadway Floor . . .	—		22,321.09
PAINTING.			
Materials	—	1,607.72	
Labor	—	4,511.90	
Total Painting	—		6,119.62
TOTAL SUPERSTRUCTURE . . .	—		$290,161.72

V.

APPROACHES.

THE portion of the east approach included in the reconstruction of the Omaha Bridge extended only from the east end of the embankment to the east end of the iron-work of the new bridge; that is, it occupied the space of the four easterly spans of the original bridge. The west approach was understood to extend from the west end of the bridge to the under crossing of the carriage-way.

The embankment east of the bridge was widened by the operating department to adapt it for a double track; but this does not appear in any of my accounts.

The easterly span of the old bridge, between Piers X. and XI., was never replaced after it was blown down in 1877. The old trestle which replaced this span was repaired, widened, and adapted to carry a double track temporarily. The three next spans were replaced by substantial double-track timber trestles. Advantage was taken of the shortening of the bridge to extend the grade on the east approach to the end of the iron-work. This grade was originally laid out as a $\frac{65}{100}$-per-cent grade (35 feet per mile), but the embankment was never completed, and the portion next to the bridge was about a $1\frac{1}{10}$-per-cent grade. As revised, the grade is made $\frac{6}{10}$-per-cent for the entire length

It was intended to fill the timber trestle during the progress of the work, but various circumstances prevented its being done. An embankment was built, however, the full width and finished at elevation 124, or 1.21 feet above the high water of 1881, and the exposed slopes of this embankment were riprapped. I should strongly advise your company to fill the entire trestle as early as can conveniently be done.

The embankment on the west approach, from the west end of the bridge to the under crossing of the carriage-way, was widened with teams and adapted to a double track.

The roadway approaches are carried down on each side of the railroad approaches at each end of the bridge, with a 5-per-cent grade, to points where the difference in elevation is such that the south roadway can be carried under the railroad tracks and connected with the north roadway, from which point of intersection the united roadways are extended to connections with surface roads. On the east side, these roadways are of trestle to the point where they unite, and an earthwork embankment from there down. On the west side, the entire roadway approaches are solid embankments, which are paved with sandstone blocks from the end of the bridge to the point where the two roadways unite. Simple toll-houses were erected at the points where the two roadways unite. The general arrangement of these roadways is shown on Plate I.

VI.

COST.

THE cost of the bridge and approaches is shown in the following table. The item of freight includes generally the freight from Chicago to the bridge site, from the sawmills to the bridge site, and from the quarries to the bridge site. In comparing the cost of this bridge with that of other structures, the cost without freight forms the most correct basis for comparison.

	Cost, exclusive of Freight Charges.		Freight Charges.		Cost, including Freight Charges.	
FOUNDATION, Pier A . . .	$40,435.97		$5,101.77		$45,537.74	
" " B . . .	30,186.98		3,396.08		33,583.06	
" " C . . .	27,039.86		3,674.63		30,714.49	
" " D . . .	22,875.39		2,370.00		25,245.39	
" " E .	25,390.72		2,700.03		28,090.75	
Foundations, Total		$145,928.92		$17,242.51		$163,171.43
MASONRY, Pier A	32,095.93		3,793.98		35,889.91	
" " B	48,754.92		7,635.00		56,389.92	
" " C . . .	54,327.08		9,119.30		63,446.38	
" " D . .	48,374.10		7,507.00		55,881.10	
" " E .	45,606.92		6,307.02		51,913.94	
Masonry, Total . . .		229,158.95		34,362.30		263,521.25
East Approach Piers .	2,979.55		328.79		3,308.34	
West " " . .	1,477.22		259.70		1,736.92	
West Abutment . . .	7,077.55		2,000.14		9,077.69	
		11,534.32		2,588.63		14,122.95
Total Substructure . .		386,622.19		54,193.44		440,815.63
Main Spans . . .	166,210.07		6,554.94		172,765.01	
Approach Spans .	73,550.05		2,852.80		76,402.85	
Railroad Floor . .	9,450.71		3,102.44		12,553.15	
Roadway Floor . . .	21,651.71		669.38		22,321.09	
Painting	6,119.62		—		6,119.62	
Total Superstructure .		276,982.16		13,179.56		290,161.72
East Approach	34,659.76		5,788.83		40,448.59	
West Approach	2,889.84		504.69		3,394.53	
Roadway Approach .	40,250.77		3,061.06		43,311.83	
Permanent Track . .	6,771.19		-		6,771.19	
Total Approaches		84,571.56		9,354.58		93,926.14
Tools and Machinery	9,730.52		—		9,730.52	
Service Track .	14,075.95		735.76		14,811.71	
Buildings	3,862.33				3,862.33	
		27,668.80		735.76		28,404.56
Engineering Salaries	29,948.25		—		29,948.25	
" Expenses . . .	2,648.28				2,648.28	
Office Expenses	2,323.93				2,323.93	
		34,920.46	—			34,920.46
Total . . .		810,765.17		77,463.34		888,228.51
Less Value of Material Sold less Cost of removing same . .	—		—		—	43,860.61
Net Cost . .	—				—	$844,367.90

This table may be condensed into the following:—

	Cost, exclusive of Freight Charges.	Freight Charges	Cost, including Freight Charges
Substructure	$386,622.19	$54,193.44	$440,815.63
Superstructure	276,982.16	13,179.56	290,161.72
Total, Bridge Proper	663,604.35	67,373.00	730,977.35
Approaches	84,571.56	9,354.58	93,926.14
Buildings, Tools, and Service Track . . .	27,668.80	735.76	28,404.56
Engineering and Expenses .	34,920.46		34,920.46
Total Cost	810,765.17	77,463.34	888,228.51
Less Value of Material Sold less Cost of removing same	—		43,860.61
Total Net Cost .	—	—	$844,367.90

In my report of May 23, 1885, the total cost of the new work within the length of the old bridge was estimated at $880,000; this providing for a solid embankment in place of the existing trestle at the east end of the bridge.

The cost above stated includes $20,994.99 expended west of the length of the old bridge, leaving the actual expenditure within the limit covered by the estimate $824,272.91; the saving from the estimate being about double the amount that will be required to build the embankment.

APPENDIX A.

LIST OF ENGINEERS, EMPLOYEES, AND CONTRACTORS.

ENGINEERS AND COMPANY'S EMPLOYEES.

NAME AND OCCUPATION.	TIME OF SERVICE
Geo. S. Morison, Chief Engineer.	
Geo. A. Lederle, Resident Engineer	Dec. 16, 1885, to June 1, 1887.
H. W. Parkhurst, Assistant Engineer of Foundations	Sept. 19, 1885, " Dec. 15, 1885.
Lewis Blickensderfer, Assistant Engineer	Oct. 26, 1885, " Mar. 31, 1886.
Ralph Modjeski, Assistant Engineer	Oct. 16, 1885, " Aug. 15, 1887.
E. P. Butts, Inspector at Quarries and Assistant Engineer	Feb. 10, 1886, " Mar. 15, 1887.
M. A. Waldo, Assistant Engineer	Sept. 1, 1886, " Nov. 24, 1886.
G. J. Bell, Assistant Engineer	Nov. 25, 1886, " Jan. 20, 1887.
E. Duryea, Jr., Resident Engineer	June 7, 1887, " Nov. 17, 1887.
S. W. Y. Schimonsky, Draughtsman	Aug. 10, 1886, " Apr. 15, 1887.
Alfred Noble, Chief Inspector of Superstructure	Feb. 8, 1886, " June 30, 1886.
R. W. Hildreth, Inspector of Superstructure	Mar. 1, 1886, " July 31, 1887.
James Saguin, Foreman of Erection	April 1, 1886, " May 31, 1887.
Robert Ross, Inspector of Masonry	Jan. 15, 1886, " Mar. 31, 1887.
Dennis Brophy, Master Mechanic	Oct 9, 1885, " July 6, 1887.
Patrick Aylward, Foreman of Pressure Work	Nov. 5, 1885, " Feb. 10, 1886.
Dennis Leonard, Foreman of Pressure Work	Feb. 11, 1886, " Feb 27, 1887.
William Wride, Sub-foreman of Erection	May 2, 1886, " Aug 17, 1887.

CONTRACTORS.

NAME.	NATURE OF WORK.
T. Saulpaugh & Co	Masonry.
Chas. Stears, Foreman of Masons.	
Oliver W. Davis, Foreman of Stone-Cutters.	
Union Bridge Co	Superstructure.
Walter A. Smith	Earthwork of Roadway Approaches.

APPENDIX B.

SPECIFICATIONS FOR MASONRY.

THE masonry will be first-class rock-face work laid in regular courses. The face stones above an elevation designated by the Chief Engineer, and including the coping, will be of granite from the quarries near St. Cloud, Minn. All other work will be of limestone from the quarries at Mankato, Minn., except spalls for backing, which shall be furnished from such source as shall require the least transportation.

The piers shall conform in all respects to the plans furnished by the Engineer.

No course shall be less than 16 inches thick, and no course shall be thicker than the course below it.

The upper and lower beds of every stone shall be at least one quarter greater in both directions than the thickness of the course, and no face stone shall measure less than 30 inches in either horizontal direction.

In general, every third stone of each course shall be a header, and there shall be at least three headers on each side of each course between the shoulders. No stone will be considered a header that measures less than 5 feet back from the face. The headers shall be so arranged as to form a bond entirely through the pier, either by bonding against a face stone in the opposite side of the course, or by bonding with a piece of backing of the full thickness of the course and not less than 3 feet square, which shall bond with a face stone on the opposite side. In all cases the interior bonding shall be further secured by placing in the course above a stone of the full thickness of the course, and at least 3 feet square, over the interior joints. Special care shall be taken with the bonding of the ice-breaker cut-water, the stones of which shall be so arranged that the face stones are supported from behind by large pieces of backing.

All joints shall be pitched to a true line, and dressed to ¼ of an inch for at least 12 inches from the face. Beds, both upper and lower, shall be pitched to a true line and dressed to ¼ of an inch. Joints shall be broken at least 15 inches on the face. The bottom bed shall always be the full size of the stone.

The pointed up-stream starlings of all the piers, for a height of 30 feet, terminating under the small coping at the offset, shall have a fine pointed face with no projection exceeding ½ inch from the pitch line of the joints. There shall be a draft line 3 inches wide around the lower edge of the belting course below the coping and on the edge of the pointed starlings. The entire coping over the whole pier, and the small copings over the starlings, shall have smooth, bush-hammered surfaces and faces. All other parts of the work shall have a rough quarry face, with no projections exceeding 3 inches from the pitch line of the joints.

The stones in the coping under the bearings of the trusses shall be at least 3 feet wide, and shall reach entirely across the pier. They shall have good beds for their entire size, and shall have a full bearing on large stones with dressed beds in the belting course below the coping.

The stones of the backing shall have dressed beds, and the backing shall be leveled up true with the face stones on the completion of every course. The backing shall generally be the same thickness as the face stones, but two thicknesses of backing may be used for one course of face stones, provided no backing is less than 12 inches thick.

All stones shall be sound, free from seams and other defects, and all limestone shall be laid on the natural bed.

All stones shall be laid in full mortar beds. They shall be lowered on the bed of mortar, and brought to a bearing with a maul. No spalls will be allowed except in small vertical openings in the backing. Thin mortar joints will not be insisted on, but the joints shall be properly cleaned on the face and pointed in mild weather, the pointing to be driven in with a calking iron.

The face stones of each entire course for the same height as the bush-hammered coping over the starling shall be doweled into those of the course below, with round dowels of 1⅛-inch iron extending 6 inches into each course; the dowels shall be from 8 to 12 inches back from the face, and 6 inches on each side of every joint; the stones of the upper course shall be drilled through before setting, after which the drill hole shall be extended 6 inches into the lower course; a small quantity of mortar shall then be put into the hole, the dowel dropped in and driven home, and the hole filled with mortar and rammed. The three courses below the coping shall have the joints bound with cramps of ⅞-inch round iron, 20 inches long between shoulders, the ends sunk 3 inches into each stone.

The mortar will be composed of cement and clean, coarse sand, satisfactory to the Engineer, in proportions varying from one to three parts of sand to one of cement, as may be directed by the Engineer for different parts of the work. When stone is laid in freezing weather the contractor shall take such precautions to prevent the mortar freezing as shall be satisfactory to the Engineer.

The stone shall be cut at the quarries.

No material shall be measured, or included in the estimate, which does not form a part of the permanent structure.

The railroad company will furnish free transportation from the quarries to the bridge site for stone actually used in the work. Any stone transported and left over will be the property of the railroad company.

The railroad company will furnish the cement for the mortar; all other materials shall be furnished by the contractor, who will also be required to furnish all tools of every description both at the quarries and on the work.

RECORD OF SINKING CAISSONS.

PIER A.

Date.	Gauge Readings. N. E.	N. W.	S. W.	S. E.	Average.	Datum.	Average Elevation of Cutting Edge.	Sunk in 24 Hours.	Elevation of Sand. N. E.	N. W.	S. W.	S. E.	Average.	Water around Caisson.	Average Penetration.	Water Gauge.	Depth Immersed.	Weight. Caisson.	Crib.	Masonry.	Sand.	Water.	Total.	Air Pressure. Indicated.	Calculated.	Reaction due to Air Pressure.	Net Weight.	Surface in Contact.	Average Friction per Square Foot.	Remarks.
1885. Dec.								Ft.										Tons.	Tons.	Tons.	Tons.	Tons.	Tons.			Tons.	Tons.	Sq. Ft.	Lbs.	
6	—	—	—	—	—	—	111.20	—	—	—	—	—	109.50	—	—	105.85														
7	—	—	—	—	—	—	110.95	0.25	—	—	—	—	109.50	—	—	105.35														
8	—	—	—	—	—	—	108.02	2.93	—	—	—	—	109.50	—	1.48	103.35														
9	—	—	—	—	—	—	106.07	1.95	—	—	—	—	109.50	—	3.43	103.27														
10	—	—	—	—	—	—	104.13	1.94	—	—	—	—	109.50	—	5.37	105.40														
11	11.21	11.20	11.11	10.89	11.20	114.56	103.46	0.67	—	—	—	—	109.50	—	6.04	105.58														
12	11.31	11.32	11.23	11.09	11.24	114.39	103.15	0.31	—	—	—	—	109.50	—	6.35	105.42														
13	12.33	12.42	12.44	12.19	12.33	115.25	102.92	0.23	—	—	—	—	109.50	—	6.58	105.75														
14	12.39	12.53	12.67	12.33	12.48	115.26	102.78	0.14	—	—	—	—	109.50	—	6.72	105.95														
15	12.63	12.80	12.93	12.54	12.73	115.35	102.62	0.16	—	—	—	—	109.50	106.12	6.88	105.95	3.50	725	—	—	3	0	728	—	1.52	177.8	550.2	1236	892	Air pressure put on at 7 A. M. Air gauge shows no pressure
16	12.12	12.23	12.36	11.99	12.18	114.79	102.61	0.01	—	—	—	—	109.50	106.11	6.89	105.16	3.50	725	—	—	3	0	728	1.00	1.52	177.8	550.2	1236	892	
17	12.33	12.40	12.73	12.42	12.47	114.86	102.39	0.22	—	—	—	—	109.50	108.71	7.11	105.55	6.32	940	69	—	5	0	1014	1.00	2.74	320.6	693.4	1283	1081	
18	13.73	13.95	13.70	14.24	13.91	114.79	100.88	1.51	—	—	—	—	109.40	107.99	8.52	105.60	7.11	940	241	—	11	0	1192	1.50	3.18	372.1	819.9	1529	107[illegible]	
19	15.16	17.01	15.31	16.87	16.15	114.73	98.64	2.24	—	—	—	—	107.80	107.51	8.16	105.30	8.87	940	259	—	11	0	1210	1.25	3.84	449.3	760.7	1468	1036	
20	16.87	17.08	16.93	16.97	16.95	114.75	97.80	0.84	—	—	—	—	106.30	107.13	8.50	105.30	9.33	940	445	—	11	1	1397	3.00	4.04	472.7	924.3	1524	1213	
21	18.69	19.20	19.61	19.05	19.14	114.59	95.45	2.35	—	—	—	—	105.95	106.95	10.50	105.33	10.50	940	584	—	15	2	1541	3.75	4.55	532.3	1008.7	1879	1068	
22	21.38	20.29	19.84	20.23	20.58	114.53	93.75	1.70	107.95	106.99	107.49	107.10	107.38	108.05	13.63	105.25	14.31	940	620	—	23	2	1585	3.50	6.20	725.4	859.6	2345	733	
23	21.96	22.32	23.66	23.34	22.62	114.22	91.40	2.35	107.26	107.41	107.06	106.88	107.15	107.50	15.75	105.32	16.10	940	845	—	46	1	1842	4.25	6.97	815.5	1026.5	2808	731	
24	25.13	25.23	26.39	26.30	25.76	114.45	88.69	2.71	108.32	106.72	106.06	106.15	106.81	107.77	18.12	105.32	19.08	940	1046	—	47	5	2038	5.00	8.26	966.4	1071.6	3222	665	
25	28.17	27.96	28.31	28.46	28.23	115.51	87.28	1.41	105.34	107.15	106.20	105.25	105.98	106.95	18.70	105.42	19.67	940	1135	—	53	5	2133	6.00	8.54	999.2	1133.8	3323	68[illegible]	
26	31.34	31.03	28.64	28.90	29.98	114.54	84.56	2.72	104.95	106.01	108.75	107.64	106.84	106.92	22.27	105.40	22.36	940	1288	—	88	0	2316	8.00	9.69	1133.7	118[illegible].3	3936	601	
27	32.78	32.58	31.34	31.48	31.99	114.06	82.07	2.49	106.08	105.73	106.07	106.18	106.07	106.95	24.00	105.45	24.88	940	1396	—	104	5	2445	8.50	10.78	1261.3	1183.7	4234	559	
28	35.25	35.21	35.58	35.60	35.41	114.20	78.79	3.28	106.25	105.99	106.62	106.30	106.29	106.89	27.50	105.40	28.10	940	1577	—	138	3	2658	11.00	12.17	1423.9	1234.1	4836	510	Ice broke in river. Moved Worthington pump on barge.
29	36.82	37.24	37.45	37.03	37.10	114.26	77.16	1.63	105.94	105.82	106.06	105.98	105.96	106.81	28.80	105.95	29.65	940	1655	—	171	5	2771	12.50	12.84	1502.3	1268.7	5060	501	
30	39.25	38.17	38.61	39.62	38.91	114.04	75.13	2.03	105.79	105.87	106.73	106.92	106.33	106.81	31.20	105.36	31.68	940	1730	—	174	3	2847	14.00	13.72	1605.2	1241.8	5473	454	
31	42.03	41.82	41.73	41.73	41.85	114.18	72.33	2.80	107.65	106.26	106.95	107.95	107.20	107.31	34.87	105.50	35.28	940	2006	—	210	1	3157	14.50	15.28	1787.8	1369.2	6104	448	
1886 Jan																														
1	44.18	44.18	44.10	43.90	44.09	113.62	69.53	2.80	107.44	106.44	106.92	107.52	107.08	107.72	37.55	105.33	38.19	940	2317	—	241	3	3501	15.00	16.54	1935.2	1565.8	6565	476	
2	47.70	47.83	47.63	47.63	47.50	113.90	66.40	3.13	106.20	106.07	106.77	107.77	106.70	107.07	40.50	105.40	40.87	940	2336	—	288	4	3568	15.25	17.70	2070.9	1497.1	7052	424	
3	53.52	53.44	53.44	53.52	53.50	114.73	61.23	5.17	106.21	105.69	106.29	106.81	106.25	107.30	45.00	105.35	46.07	940	2532	—	373	11	3856	15.50	19.96	2333.3	152[illegible].7	7790	391	
4	57.87	57.80	57.76	57.80	57.81	116.10	58.29	2.94	109.23	110.30	110.34	110.10	110.24	111.04	51.95	105.40	52.75	940	2672	—	506	8	4026	17.00	22.85	2673.4	1352.6	8930	333	Sand pump shut down at 8 A. M. Bad weather.
5	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	103.90	—	940	2672	—	—	—	—	19.00	—	—	—	—	—	Sand pump shut down for want of coal
6	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	103.25	—	940	2672	—	—	—	—	19.00						
7	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	103.50	—	940	2672	—	—	—	—	19.25	—	—	—	—	—	No work going on. Blizzard.
8	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	104.10	—	940	2672	—	—	—	—	—	—	—	—	—	—	No work going on Blizzard
9	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	105.80	—	940	2672	—	—	—	—	18.25	—	—	—	—	—	River closed Blizzard
10	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	106.10	—	940	2672	—	—	—	—	18.50						
11	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	106.00	—	940	2672	—	—	—	—	18.50						
12	—	—	—	—	—	—	58.29	0.00	—	—	—	—	—	—	—	106.00	—	940	2672	—	—	—	—	18.75	—	—	—	—	—	Sand pump started at 11 A. M.
13	58.96	58.99	59.17	59.18	59.06	115.10	56.04	2.25	106.12	109.11	108.93	105.92	107.27	110.00	51.50	106.25	53.96	940	2829	156	496	29	4450	19.25	23.38	2735.5	1714.5	8856	387	
14	61.56	61.53	61.55	61.60	61.56	115.14	53.58	2.46	105.58	106.61	106.59	106.54	106.33	106.69	52.75	106.50	53.11	940	2829	267	520	4	4560	20.50	23.01	2692.2	1867.8	9061	412	
15	63.36	63.62	63.53	63.80	63.58	115.10	51.52	2.06	105.84	105.48	105.57	105.10	105.49	109.30	53.98	106.65	57.78	940	2829	367	544	40	4720	20.50	25.03	2928.5	1791.5	9263	387	
16	63.73	53.76	63.77	63.93	63.80	115.23	51.43	0.09	105.50	105.97	105.96	105.30	105.68	107.50	54.25	106.50	56.07	940	2829	367	549	19	4704	23.00	24.29	2841.9	1862.1	9307	400	
17	66.33	66.39	66.35	66.49	66.40	115.65	49.25	2.18	109.32	108.14	108.50	108.24	108.55	110.50	59.30	106.30	61.25	940	2829	462	719	50	5000	23.00	26.53	3104.0	1896.0	9996	319	
18	—	—	—	—	—	—	49.25	0.00	—	—	—	—	—	—	—	106.80	—	940	2829	558	—	—		24.00						
19	—	—	—	—	—	—	49.25	0.00	—	—	—	—	—	—	—	106.50	—	940	2829	667	—	—	—	24.00						
20	—	—	—	—	—	—	49.25	0.00	—	—	—	—	—	—	—	106.50	—	940	2829	667	—	—	—	24.00						
21	68.10	68.11	68.21	68.24	68.16	115.26	47.08	2.17	110.10	110.25	110.05	109.87	110.06	110.40	62.98	107.15	63.32	940	2829	743	922	10	5414	25.50	27.43	3209.3	2234.7	10441	428	
22	—	—	—	—	—	—	47.08	0.00	—	—	—	—	—	—	—	107.30	—	940	2829	752	—	—	—	25.00						
23	70.26	70.20	70.16	70.22	70.21	115.24	45.23	1.85	109.98	107.24	109.02	109.82	109.03	110.40	63.80	107.30	65.17	940	2829	844	968	40	5621	24.00	28.28	3202.9	2318.1	10539	439	
24	—	—	—	—	—	—	45.23	0.00	—	—	—	—	—	—	—	107.35	—	940	2829	844	—	—	—	26.00						
25	72.30	72.21	72.15	72.26	72.23	115.19	42.96	2.27	109.99	109.98	110.04	109.83	109.96	110.26	67.00	107.35	67.30	940	2829	844	1155	9	5777	26.00	29.15	3410.6	2366.4	10923	433	
26	—	—	—	—	—	—	42.96	0.00	—	—	—	—	—	—	—	107.20	—	940	2829	927	—	—	—	26.00						
27	74.88	74.74	74.67	74.83	74.78	115.39	40.61	2.35	110.01	109.95	109.92	109.96	109.96	110.14	69.35	107.10	69.53	940	2829	927	1292	5	5993	27.50	30.11	3513.8	2479.[illegible]	11202	442	
28	77.35	77.25	77.15	77.25	77.25	115.34	38.09	2.52	108.99	109.29	109.19	109.19	109.16	109.89	71.08	107.15	71.80	940	2829	1022	1391	23	6205	27.00	31.10	3638.7	2566.3	11407	450	
29	79.11	78.93	78.95	79.02	79.00	115.60	36.60	1.49	109.89	110.07	109.95	109.88	109.95	107.10	73.35	107.10	70.50	940	2829	1102	1532	0	6403	28.00	30.53	3536.0	2867.0	11675	491	No water standing in pit around caisson.
30	—	—	—	—	—	—	36.60	0.00	—	—	—	—	—	—	—	107.10	—	940	2829	1183	—	—	—	28.00						
31	81.50	81.37	81.41	81.50	81.44	117.16	35.72	0.88	109.70	109.70	109.40	109.60	109.60	109.76	73.88	107.10	74.04	940	2829	1183	1563	5	6520	28.00	32.07	3752.2	2767.8	11737	472	Cutting edge on bed-rock at 7 P. M.

APPENDIX C.—CONTINUED.

RECORD OF SINKING CAISSONS.

PIER B.

Date	Gage Readings. N. E.	N. W.	S. W.	S. E.	Average	Datum	Average Elevation of Cutting Edge	Sunk in 24 Hours	Elevation of Sand. N. E.	N. W.	S. W.	S. E.	Average	Average Penetration of Caisson	Water Gauge	Depth Immersed	Weight. Caisson	Crib	Masonry	Sand	Water	Total	Air Pressure. Indicated	Calculated	Reaction due to Air Pressure	Net Weight	Surface in Contact	Average Friction per Square Foot	Remarks
1886. Jan.																	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.			Tons.	Tons.	Sq. Ft.	Lbs.	
31	—	—	—	—	—	—	111.25	—	—	—	—	—	—	—	—	—					—	—		—	—	—		—	Cutting edge at this elevation when caisson built.
Feb. 1	—		—	—	—	—	106.90	4.35		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Lowered on screws until cutting edge rested on ice.
2	—	—	—	—	—	—	101.25	5.65																					
3		—	—			—	101.25	0.00	—	—	—	—		—							—		—	—	—			—	Commenced concreting.
4	—		—		—	—	97.30	3.95					—	—	—		356	—	—	—	—	356							
5			—	—		—	97.30	0.00			—		—	—	106.25	8.95	475	—		—	—	475							
6	14.00	14.60	14.?0	14.10	14.35	106.50	92.15	5.15	—	—	—	—			106.20	14.05	574					574	5.00	—	—	—	—	—	Air pressure put on at 4 P. M. Sand pump started 5 P. M.
7	15.50	17.75	1?.49	1?.?6	1?.85	105.?7	89.72	2.43	—				91.95	2.23	105.57	15.85	870	—	—		18	888	5.00	6.86	801	87	401	434	
8	18.90	18.90	19.83	19.83	19.37	105.50	86.13	3.59					91.90	5.77	105.50	19.37	940	239	—	5	31	1215	5.50	8.39	979	236	1038	455	
9	31.07	31.?4	30.83	30.67	30.95	113.81	82.86	3.2	—	—	—	—	91.86	9.00	105.57	22.71	940	558		16	42	1550	6.50	9.87	1152	398	1611	493	
10	34.?8	34.10	34.30	34.39	34.27	113.94	79.67	3.19	—	—		—	91.75	12.08	105.55	25.88	940	748	—	19	28	1735	8.00	11.21	1308	427	2162	395	Sand pump stopped at 2 P. M. Waiting for masonry.
11	36.73	36.99	36.74	36.58	36.76	114.39	77.63	2.04	—				91.83	14.20	105.53	27.90	940	991	—	23	66	2020	10.50	12.08	1410	610	2473	493	First course of masonry laid out
12	36.56	36.07	35.93	35.90	36.2?	113.61	77.34	0.29		—	—		91.80	14.46	105.50	28.16	940	991	165	23	68	2187	10.50	12.19	1423	764	2508	609	Waiting for masonry
13	38.03	37.93	37.17	37.10	37.58	114.77	77.19	0.15	—	—	—	—	91.55	14.36	105.?6	28.57	940	991	315	23	73	2342	12.00	12.37	1434	908	2494	730	Sand pump started at 3 P. M.
14	41.84	41.00	40.86	41.3?	41.39	113.47	72.08	5.11	—			—	91.41	19.33	105.80	33.78	940	991	4?3	60	108	25??	13.00	14.63	1707	855	3441	497	
15	46.09	46.01	45.28	4?.43	4?.00	113.39	67.09	4.39					91.48	24.?9	105.88	38.19	940	991	610	102	203	2846	15.00	16.54	1930	916	4199	436	
16	48.33	48.74	48.15	48.38	48.28	113.91	65.63	2.06			—	—	90.?6	24.63	105.86	40.23	940	991	1004	110	274	3319	16.00	17.43	2033	1246	4343	574	
17	51.09	50.88	50.64	50.94	50.89	113.24	62.35	3.28	88.95	8?.95	92.?5	91.95	90.45	28.10	105.95	43.60	940	991	1114	1?2	316	3413	20.00	18.88	2?04	1709	3923	491	
18	52.42	52.20	51.63	51.91	52.04	112.83	60.??	1.36	—		—		90.65	29.86	106.15	45.36	940	991	1244	110	350	3585	23.00	19.64	229?	1293	5??8	495	Struck mud on south end of chamber
19	49.05	48.85	48.85	49.05	48.95	106.35	57.40	3.39					90.?5	33.?5	106.35	48.95	940	991	1?14	262	389	3826	26.00	21.19	?173	1353	5739	471	Pier settled at 6.30 A. M. This is first settle by reducing air pressure.
20	58.57	58.42	58.20	58.??	58.41	113.71	55.30	2.10		—		—	90.30	35.00	106.46	51.16	940	991	1376	324	408	40?9	26.00	22.15	2586	1463	5986	488	Pier settled at 4.30 A. M. and at 6 P. M.
21	60.72	60.63	60.68	60.84	60.72	113.25	52.53	2.77	85.56	87.56	8?.?6	9?.?5	88.3?	3?.78	106.56	54.03	940	991	1480	336	478	4155	2?.00	23.39	2730	1425	6096	467	
22	63.66	63.62	63.78	63.82	63.72	113.??	49.65	2.88	—				87.53	3?.88	106.71	57.06	940	991	1?65	451	538	4685	26.00	24.71	2884	1801	6355	567	Pier settled at 2.30 P. M.
23	68.19	68.25	68.13	68.18	68.19	113.33	45.1?	4.53	85.89	86.89	87.89	90.89	87.89	42.75	106.89	61.75	940	991	1986	674	570	511?	27.50	26.74	3131	1985	6989	568	Pier settled at ?.45 P. M.
24	—	—		—	—	—	45.14	0.00	—	—	—	—	87.89	42.75	107.00	61.86	940	991	1986	674	573	5114	31.00	2?.?8	3126	1988	6989	569	Waiting for masonry
25	65.28	65.42	65.28	65.10	65.?9	107.46	42.17	2.97	85.40	86.?	86.96	91.43	87.58	45.41	107.26	65.09	940	991	1986	822	548	5207	33.00	28.18	3289	1978	7317	546	Pier settled at 3.30 P. M.
26			—	—			42.17	0.00				—	87.58	45.41	107.46	65.29	940	991	2089	8??	554	5376	33.00	28.27	3300	2076	7310	567	Waiting for masonry Pier settled at 3.30 P. M.
27	76.62	76.79	76.71	76.55	76.67	115.15	38.48	3.69	85.00	86.00	87.00	90.00	87.00	48.52	108.00	69.52	940	991	2332	950	598	5811	35.50	30.10	3513	2298	7710	596	" "
28	—	—	—	—	—	—	38.48	0.00	—		—	—	87.00	48.52	108.15	69.67	940	991	2380	950	562	5823	35.50	30.17	3521	2302	7710	598	" "
Mar. 1	—	—	—	—			38.48	0.00			—		87.00	48.52	108.59	70.11	940	991	2494	950	615	5990	38.00	30.36	3514	2446	7710	634	Waiting for masonry. Pier settled at 5 P. M.
2	79.99	80.15	79.98	79.86	80.00	115.08	35.08	3.40	82.98	85.98	8?.98	70.98	86.98	51.90	108.98	73.90	940	991	2582	1115	640	6208	38.00	32.00	3735	2533	8135	623	" "
3	—			—	—	—	35.08	0.00	—	—	—	—	86.98	51.90	109.29	74.21	940	991	2677	1115	669	6392	39.00	3?.13	3750	2642	8135	649	Pier settled at 6.45 P. M.
4	76.48	76.73	76.95	76.8?	76.76	109.58	32.82	2.26	81.53	83.73	86.53	89.53	85.25	52.43	109.53	76.71	940	991	2767	1141	705	6544	40.00	33.21	3876	2668	8201	651	
5	77.86	77.98	7?.?7	77.73	7?.84	109.69	31.85	0.97	80.66	80.?	84.66	88.66	83.66	51.81	109.66	77.81	940	991	2767	1078	764	6540	40.50	33.69	3932	2608	8123	64?	Pier settled at 11.45 A. M. and 5.45 P. M.
6	85.43	85.57	85.?8	85.62	85.50	116.?7	30.69	1.16	82.04	86.?1	79.61	76.14	8?.?4	50.45	109.?4	78.95	940	991	2800	1023	837	6651	40.50	34.18	3989	2662	7954	669	Pier settled at 4.20 P. M.
7	86.88	87.00	87.02	86.95	86.96	116.18	29.?2	1.47	79.39	77.39	80.39	84.39	80.39	51.17	109.64	80.4?	940	991	2946	1057	839	6773	40.50	34.8?	4064	2709	80?3	673	Cutting edge on bed-rock at 4 P. M.
8	87.39	87.54	87.59	87.63	87.54	116.16	28.62	0.60					80.99	52.37	109.39	80.77	940	991	2946	1115	849	6841	—	34.97	4082	27??	8193	673	

APPENDIX C. — CONTINUED.

RECORD OF SINKING CAISSONS.

PIER C.

Date	Gauge Readings. N. E.	N. W.	S. W.	S. E.	Average.	Datum.	Average Elevation of Cutting Edge.	Sunk in 24 Hours.	Elevation of Sand. N. E.	N. W.	S. W.	S. E.	Average of 12 Soundings.	Average Penetration of Caisson.
1886 Sept.														
14	—		—	—	—	—	111.14	—	—	—	—	—		—
15			—			—	111.14		—	—	—	—		—
16	[illegible]	[illegible]	7.10	7.20	7.08	106.70	99.60	1.54	—	—	—	—	—	—
17	7.90	7.00	7.50	7.50	7.48	106.65	99.47	0.49	98.65	97.15	91.65	98.75	96.55	—
18	21.15	21.06	22.47	22.92	21.90	118.68	96.78	2.39	97.60	98.30	91.60	96.80	96.08	—
19	23.70	22.54	22.55	[illegible]	23.15	118.57	95.42	1.36	97.00	98.50	92.50	97.00	97.64	[illegible]
20	26.59	25.84	26.30	27.58	26.67	118.63	91.96	3.46	96.50	98.00	91.60	97.50	97.53	5.57
21	30.73	30.30	[illegible]	[illegible]	[illegible]	118.68	87.67	4.29	98.45	97.95	92.45	97.15	97.00	9.39
22	29.55	28.75	28.29	[illegible]	28.95	114.40	85.45	2.22	96.40	97.90	93.40	97.40	97.32	11.87
23	29.48	28.64	28.15	29.06	28.84	114.26	85.42	0.03	96.40	97.90	93.40	97.90	97.54	12.09
24	32.98	32.87	32.48	32.55	32.72	114.81	82.09	3.33	95.90	99.40	92.40	99.40	97.69	15.60
25	34.48	34.16	34.13	34.38	34.29	114.70	80.41	1.68	101.30	100.30	95.30	101.00	99.86	19.45
26	38.40	[illegible]	38.72	38.34	38.56	114.93	76.36	4.05	97.40	102.40	97.40	103.40	101.28	24.97
27	40.45	40.87	40.94	40.48	40.68	114.88	74.20	2.16	99.40	101.40	98.90	103.40	101.83	27.63
28	43.91	43.98	41.25	44.12	44.06	114.65	70.59	3.61	100.60	101.70	102.90	104.40	102.30	31.61
29	47.54	47.44	47.27	47.29	47.38	114.66	67.28	3.31	102.40	98.90	102.60	104.40	101.75	34.47
30	[illegible]	51.56	51.50	51.67	51.61	114.83	63.22	4.06	98.90	99.00	103.90	101.90	100.27	37.05
Oct.														
1	52.30	52.14	51.97	52.15	52.14	114.91	62.77	0.45	99.45	99.45	103.45	100.95	99.66	36.89
2	54.30	54.09	54.14	54.38	54.23	114.65	60.47	2.35	99.45	99.45	104.45	99.45	99.37	38.95
3	58.52	58.24	58.41	58.69	58.46	114.67	56.21	4.21	96.20	101.40	103.30	99.20	98.76	42.55
4	[illegible]	[illegible]	61.12	61.27	61.00	114.57	53.57	2.62	96.20	96.20	102.70	100.60	98.43	44.86
5	64.23	64.10	[illegible]	[illegible]	64.02	114.73	50.71	2.86	96.15	95.65	101.15	105.15	98.47	47.76
6	66.92	66.93	[illegible]	66.88	66.91	114.72	47.81	2.90	96.60	95.10	101.10	104.60	98.42	50.61
7	69.10	[illegible]	69.41	69.37	69.55	114.56	45.01	2.80	96.50	95.00	101.00	104.00	97.93	52.92
8	73.79	[illegible]	73.62	73.55	[illegible]	118.50	44.85	0.16	97.10	95.10	103.10	105.10	98.64	53.79
9	73.97	74.05	73.85	73.90	[illegible]	[illegible]	44.75	0.10	98.00	95.00	102.50	104.50	98.89	54.14
10	76.30	76.38	[illegible]	76.63	76.49	118.56	42.07	2.68	97.00	94.00	103.00	104.00	98.75	56.68
11	76.65	76.75	76.81	[illegible]	[illegible]	118.55	41.81	0.26	97.50	94.50	103.50	104.00	99.54	57.73
12	79.13	79.24	79.10	79.06	79.13	118.44	39.31	2.50	96.40	93.90	104.90	103.40	99.13	59.82
13	79.43	79.51	79.43	79.38	79.44	118.65	39.21	0.10	95.90	93.90	104.40	102.90	99.19	59.98
14	81.69	[illegible]	81.94	81.96	81.84	118.51	36.67	2.54	95.90	93.90	105.30	102.90	[illegible]	62.43
15	82.38	82.46	82.54	82.56	82.48	118.24	35.76	0.91	95.85	93.65	104.35	101.85	98.60	62.84
16	84.69	84.71	84.61	84.67	84.67	118.59	33.92	1.84	95.30	94.30	104.30	100.80	97.90	63.98
17	84.74	84.76	84.68	84.74	84.74	118.65	33.91	0.01	93.85	93.80	104.85	100.04	98.04	[illegible]
18	83.33	83.31	[illegible]	83.01	83.14	114.79	31.65	2.26	93.85	94.35	103.35	100.05	97.68	66.03
19	[illegible]	87.18	[illegible]	[illegible]	86.99	114.63	31.64	0.01	93.35	94.35	103.85	100.35	97.85	66.21
20	84.32	84.37	84.50	84.39	84.33	114.40	30.07	1.57	90.40	94.80	104.30	103.80	98.00	67.93

Date	Water Gauge.	Depth Immersed.	Weight. Caisson. Tons.	Crib. Tons.	Masonry. Tons.	Sand. Tons.	Water. Tons.	Total. Tons.	Air Pressure. Indicated.	Calculated.	Reaction due to Air Pressure. Tons.	Net Weight. Tons.	Surface in Contact. Sq. Ft.	Average Friction per Square Foot. Lbs.	Remarks.
1886 Sept.															
14	106.80		239	-	—	—	-	239	—	—		239	—	—	Caisson suspended on screws, commenced lowering
15	106.70	—	239	—	—	—	—	239	—	—	—	239	—	—	Commenced concreting 3 P. M.
16	106.70	7.08	355		—	—	—	355	—			355			
17	106.65	7.48	514		-	-	—	514	—	—		514	—	—	Stopped concreting 12 M. Air pressure put on 5 P. M. Started concreting 6 P. M.
18	106.60	9.82	617		—	—		617	6.25	4.25	516	101	—	—	Stopped concreting 6 A. M. Started sand pump 10 A. M.
19	106.50	11.08	855	11	-	—	5	871	8.75	4.50	583	288	404	1425	
20	106.50	14.54	975	34	—	—	22	1031	9.00	6.29	764	267	1014	576	
21	106.45	18.78	975	221	—	8	31	1235	10.50	8.13	987	248	1709	290	
22	106.40	20.95	975	503	—	16	35	1529	11.50	9.07	1101	428	2137	400	Waiting all day till concrete sets, for first course of masonry.
23	106.40	20.98	975	520	—	17	35	1547	11.50	9.08	1102	445	2142	415	First course of masonry laid out
24	106.40	21.31	975	520	178	33	33	1739	13.50	10.53	1278	461	2267	406	
25	106.50	26.09	975	520	409	56	82	2042	13.50	11.30	1372	670	3476	385	
26	106.40	30.04	975	520	604	123	110	2332	15.00	13.01	1579	753	4526	332	
27	106.40	32.20	975	520	768	216	113	2592	18.00	13.94	1687	905	4907	345	
28	106.40	35.81	975	520	1063	387	107	3052	18.50	15.58	1891	1161	5432	427	
29	106.40	39.12	975	520	1197	516	117	3325	20.00	16.94	2056	1269	5804	437	
30	106.40	43.18	975	520	1174	633	162	3760	21.50	18.70	2270	1490	6135	485	
Oct.															
1	106.45	43.68	975	520	1474	626	178	3773	21.50	18.91	2296	1477	6118	483	
2	106.45	46.03	975	520	1648	721	190	4054	23.00	19.93	2419	1625	6383	509	
3	106.70	49.99	975	520	[illegible]	800	204	4344	27.00	21.64	2627	1727	6846	504	First settle of caisson by blowing off air pressure at 6.20 P. M. on the 2d
4	106.70	52.63	975	520	1991	989	216	[illegible]	27.50	22.79	[illegible]	1924	7110	541	
5	106.15	55.44	975	520	2203	1142	217	5147	29.00	24.00	2914	2233	7509	595	
6	106.10	[illegible]	975	520	2514	1283	222	5514	30.00	25.24	3064	2450	7868	622	
7	106.00	60.99	975	520	2625	1399	236	5755	31.00	26.41	3206	2549	8158	625	
8	106.10	[illegible]	975	520	2755	1443	218	5911	31.00	[illegible]	3219	[illegible]	[illegible]	651	Struck gravel and some clay. Sacking out material
9	106.00	[illegible]	975	520	2735	1475	209	5934	31.50	26.52	3219	2715	8304	653	Gravel and sand with some clay. Sacking out material
10	106.00	63.93	975	520	2840	1591	216	6142	32.00	27.68	3360	2782	8676	645	" " " " "
11	106.00	64.19	975	520	2840	1646	193	6174	32.00	27.79	3374	2800	[illegible]	630	" " " " "
12	105.90	66.59	975	520	3012	1761	204	6472	33.00	28.83	3500	[illegible]	9014	659	
13	105.90	66.69	975	520	3151	1765	203	6614	33.00	28.88	3406	3108	9036	689	
14	105.90	69.23	975	520	[illegible]	1894	[illegible]	6843	34.00	29.98	3040	[illegible]	9335	656	
15	105.85	70.09	975	520	3303	1916	219	6933	34.00	30.35	3684	3249	[illegible]	651	
16	105.80	71.88	975	520	3303	1978	243	7021	34.50	31.12	[illegible]	[illegible]	9526	681	
17	105.85	71.94	975	520	3303	1985	[illegible]	7021	35.50	31.15	3782	3239	9546	678	
18	105.85	[illegible]	975	520	3303	2087	256	7141	36.50	32.13	3901	3240	9770	663	
19	105.85	74.31	975	520	3373	2099	251	7148	37.00	32.13	3901	3247	9774	641	The levels were taken after settle at 5.20 P. M. on the 18th
20	105.85	75.78	975	520	3303	2197	246	7241	37.50	32.81	3953	[illegible]	10012	651	Caisson on bed-rock at 5.20 P. M. on the 19th.

APPENDIX C.—CONTINUED.

RECORD OF SINKING CAISSONS.

PIER D.

Date.	Gauge Readings N. E.	Gauge Readings N. W.	Gauge Readings S. W.	Gauge Readings S. E.	Gauge Readings Average.	Datum.	Average Elevation of Cutting Edge.	Sunk in 24 Hours.	Elevation of Sand N. E.	Elevation of Sand N. W.	Elevation of Sand S. W.	Elevation of Sand S. E.	Elevation of Sand Average of 12 Soundings.	Average Penetration of Caisson.	Water Gauge.	Depth Immersed.	Weight Caisson.	Weight Crib.	Weight Masonry.	Weight Sand.	Weight Water.	Weight Total	Air Pressure Indicated.	Air Pressure Calculated.	Reaction due to Air Pressure.	Net Weight.	Surface in Contact.	Average Friction per Square Foot.	Remarks.
1886 Oct																	Tons.		Tons.	Tons.	Tons.	Tons.			Tons.	Tons.	Sq. Ft.	Lbs.	
27	—	—	—	—	—	—	110.23	—	—	—	—	—	—	—	105.80	—	234		—	—	—	234	—	—	—	234	—	—	Caisson suspended on screws; began lowering at 12 noon
28	0.50	0.50	0.50	0.50	0.50	105.90	105.40	4.83	—	—	—	—	—	—	105.90	0.50	234		—	—	—	234	—	—	—	234	—	—	No lowering done on the 28th, 29th, 30th, or 31st.
Nov 1	4.80	4.80	4.80	4.80	4.80	105.70	100.90	4.50	93.70	94.70	96.20	93.20	95.18	—	105.70	4.80	234		—	—	—	234	—	—		234			
2	10.70	10.70	10.70	10.70	10.70	105.70	95.00	5.90	90.70	92.70	95.70	93.70	94.28	—	105.70	10.70	490		—	—	—	490	—	—	—	490	—	—	Caisson landed; removing screws at south end.
3	12.40	10.70	9.10	11.30	10.88	105.60	94.72	0.28	90.10	92.60	95.60	92.60	93.79	—	105.60	10.88	841		—	—	—	841	—	—	—	841	—	—	All screws removed. Air pressure put on at 11 A. M.
4	26.41	26.85	27.50	27.47	27.06	118.24	91.18	3.54	90.10	91.60	95.60	100.60	95.26	4.08	105.60	14.42	992		—	—	15	1007	7.50	6.24	728	279	734	760	First course of masonry laid out at 4 P. M
5	23.37	23.47	23.36	23.58	23.44	114.34	89.21	1.97	88.70	90.70	95.70	102.70	96.09	6.88	105.70	16.49	992		30	3	19	1044	9.00	7.14	833	211	1238	341	
6	25.83	25.31	27.08	26.95	26.54	114.47	87.93	1.28	89.30	90.80	95.80	102.80	96.05	8.12	105.80	17.87	992		233	5	23	1253	10.00	7.74	903	350	1455	481	
7	31.13	30.97	31.25	31.37	31.18	113.93	82.75	5.18	87.90	90.60	101.90	102.90	96.84	14.09	105.90	23.15	992		477	27	98	1594	13.00	10.02	1169	425	2495	340	
8	34.87	35.43	34.91	34.39	34.90	113.67	78.77	3.98	87.95	90.95	101.95	101.95	96.62	17.85	105.95	27.18	992		773	46	198	2009	15.00	11.77	1374	635	3200	396	
9	37.69	38.02	38.31	37.97	38.00	113.79	75.79	2.98	87.00	90.00	103.00	100.00	96.08	20.29	106.00	30.21	992		962	93	238	2285	16.50	13.08	1527	758	3439	441	
10	42.09	42.66	43.21	43.14	42.92	113.74	70.82	4.97	89.00	91.00	104.00	99.00	95.46	24.64	106.00	35.18	992		1265	259	273	2789	18.50	15.23	1778	1011	4042	500	
11	47.19	47.38	47.38	47.09	47.26	113.82	66.61	4.21	89.10	90.60	102.10	98.10	94.68	28.07	106.10	39.49	992		1469	422	316	3199	20.50	17.10	1996	1203	4530	531	
12	49.52	49.80	49.76	49.34	49.61	113.74	64.13	2.48	89.10	90.10	104.10	97.10	93.77	29.64	106.10	41.97	992		1627	497	346	3462	24.00	18.17	2121	1341	4736	565	
13	52.33	52.29	52.30	52.20	52.28	113.77	61.49	2.64	88.30	88.30	103.30	96.30	92.93	31.44	106.30	44.81	992		1842	584	382	3800	24.00	19.40	2264	1536	4993	615	
14	58.26	58.15	58.08	58.03	58.13	113.68	55.55	5.94	87.40	87.40	102.40	96.40	92.40	36.85	106.40	50.85	992		2052	850	411	4305	25.00	22.02	2571	1734	5729	605	
15	60.47	60.43	60.42	60.32	60.41	113.79	53.38	2.17	88.00	88.00	103.50	96.50	92.17	38.79	106.50	53.12	992	No Crib.	2237	948	426	4603	27.00	23.00	2684	1919	6002	639	Struck gravel with some clay at north end of caisson
16	54.90	54.90	54.30	54.30	54.60	106.55	51.95	1.43	87.55	87.55	103.55	97.05	92.43	40.48	106.55	54.60	992		2353	1033	423	4801	28.00	23.64	2759	2042	6220	656	Strong snow-storm prevented laying masonry. River closed above bridge.
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	106.60	—	992		2353	—	—	—	29.00	—	—	—	—	—	No levels or soundings taken. Snow-storm and blizzard. Sacking out gravel.
18	64.87	64.78	64.41	64.40	64.61	114.25	49.64	2.31	—	—	—	—	—	—	104.20	54.56	992		2353	—	—	—	29.00	23.62	2757	—	—	—	No soundings taken on account of ice
19	64.99	64.91	64.54	64.53	64.74	114.33	49.59	0.05	90.10	88.10	103.10	99.10	95.06	45.47	105.10	55.51	992		2353	1262	300	4907	29.00	24.04	2809	2098	6668	629	
20	64.96	64.85	64.49	64.47	64.69	114.27	49.58	0.01	90.20	88.20	102.20	98.20	94.99	45.41	105.20	55.62	992		2353	1259	305	4909	29.00	24.08	2811	2098	6660	630	Hoisting out gravel. Working all day to get derrick-boat off sand-bar.
21	—	—	—	—	—	—	49.58	0.00	87.88	88.88	99.88	98.88	95.21	45.63	104.88	55.30	992		2353	1276	271	4892	29.00	23.94	2782	2110	6687	631	
22	65.44	65.32	65.09	65.11	65.24	113.16	47.92	1.66	88.55	88.55	98.58	98.55	94.88	46.96	104.55	56.63	992		2401	1343	287	5023	30.00	24.52	2862	2161	6846	646	
23	66.06	65.97	65.35	65.40	65.69	113.13	47.44	0.48	90.00	90.00	98.00	99.00	95.50	48.06	105.00	57.56	992		2498	1401	286	5177	30.00	24.92	2909	2268	6966	651	
24	72.17	72.08	[illegible]	71.37	71.72	118.13	46.47	0.97	89.10	91.10	98.10	99.10	96.93	50.46	105.10	58.63	992		2678	1529	249	5448	30.50	25.39	2963	2485	7279	682	Masonry 9.28 ft. above water surface.
25	72.81	72.79	72.23	72.17	72.50	118.01	46.01	0.46	91.40	90.90	98.40	98.40	96.44	50.93	105.40	59.39	992		2678	1527	273	5470	30.50	25.72	3002	2468	7775	678	
26	73.55	73.55	73.11	73.07	73.32	118.35	45.03	0.98	89.20	90.20	97.20	100.20	96.87	51.84	105.20	60.17	992		2764	1602	272	5630	30.50	26.05	3040	2590	7448	695	
27	73.40	73.38	72.76	72.72	73.07	117.74	44.67	0.36	89.10	90.10	97.10	98.10	96.77	52.10	105.10	60.43	992		2764	1620	256	5632	30.50	26.17	3055	2577	7478	689	
28	72.73	72.69	72.23	72.19	72.46	116.24	43.78	0.89	89.00	90.00	96.00	98.00	96.75	52.97	105.00	61.22	992		2764	1662	252	5670	31.50	26.51	3094	2576	7584	679	
29	72.72	72.69	72.55	72.51	72.62	115.24	42.62	1.16	90.30	90.30	96.30	98.30	96.97	54.35	105.30	62.68	992		2764	1737	259	5752	31.50	27.14	3168	2584	7750	667	
30	72.76	72.70	72.58	72.56	72.65	114.39	41.74	0.88	90.40	89.40	98.40	100.40	97.15	55.41	105.40	63.66	992		2764	1795	257	5808	31.50	27.56		2591	7880	658	Caisson settled for the first time by relieving pressure at 3 P. M., and landed on bed rock on west side
Dec 1	72.77	72.81	72.84	72.76	72.79	113.43	40.64	1.10	90.70	90.70	96.70	99.70	97.03	56.39	105.70	65.06	—		—	—	—	—	32.00	28.17	3217				

APPENDIX C.—CONTINUED.

RECORD OF SINKING CAISSONS.

PIER E.

Date	Gauge Readings. N. E.	N. W.	S. W.	S. E.	Average.	Datum.	Average Elevation of Cutting Edge	Sunk in 24 Hours.	Elevation of Sand. N. E.	N. W.	S. W.	S. E.	Average of 12 Soundings.	Average Penetration of Caisson.	Water Gauge.	Depth Immersed.
1887 Jan.																
5	-	-	—				110.09	—	—	—	—	—	—	—	—	—
6	7.10	7.10	7.30	7.30	7.25	107.37	100.12	9.87	91.37	95.37	92.37	93.87	[illegible]	—	107.37	7.25
7	11.10	11.10	11.10	11.10	11.10	107.47	96.37	3.75	[illegible]	95.47	92.47	94.47	[illegible]	—	107.47	11.10
8	12.00	12.10	12.10	12.00	12.10	107.55	95.45	0.92	91.55	94.55	93.05	93.55	91.84	—	107.55	12.10
9	13.50	13.50	13.50	13.50	13.50	107.69	94.15	1.30	92.65	94.15	92.02	93.15	91.61	—	107.65	13.15
10	15.00	15.00	15.00	15.00	15.00	107.77	[illegible]	1.38	[illegible]	93.77	91.77	92.77	91.59	—	107.77	15.00
11	[illegible]	26.94	[illegible]	27.33	27.14	118.14	91.00	[illegible]	92.88	91.88	92.88	92.88	91.53	0.57	107.88	16.88
12	23.21	23.20	23.05	23.13	23.15	113.91	[illegible]	[illegible]	92.96	93.46	92.96	[illegible]	91.84	1.08	107.96	17.20
13	27.84	[illegible]	[illegible]	26.87	27.31	117.12	89.81	0.95	91.01	93.01	93.01	[illegible]	[illegible]	1.10	108.01	18.20
14	21.71	[illegible]	27.58	27.58	[illegible]	107.17	89.03	0.78	92.06	91.06	[illegible]	93.06	91.06	2.03	108.06	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	32.64	107.17	84.53	4.50	91.13	91.13	[illegible]	93.13	91.63	[illegible]	108.13	23.00
16	35.06	34.98	34.83	[illegible]	34.93	116.54	81.61	[illegible]	89.10	89.10	95.60	94.10	91.63	10.32	108.10	[illegible]
17	37.34	[illegible]	37.80	38.03	37.55	107.15	79.60	2.01	[illegible]	91.75	[illegible]	94.75	[illegible]	12.61	108.25	[illegible]
18	38.94	38.84	[illegible]	[illegible]	[illegible]	115.90	77.06	2.54	88.30	89.30	96.30	95.80	91.89	[illegible]	108.30	[illegible]
19	[illegible]	42.45	[illegible]	[illegible]	[illegible]	117.35	[illegible]	2.33	[illegible]	[illegible]	97.36	94.26	92.59	17.86	[illegible]	33.53
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	117.13	70.25	[illegible]	88.10	88.10	94.10	94.10	90.39	20.14	108.10	[illegible]
21	46.90	46.90	46.90	[illegible]	[illegible]	117.15	[illegible]	[illegible]	87.97	[illegible]	94.97	[illegible]	91.01	20.81	[illegible]	[illegible]
22	50.50	50.60	[illegible]	50.18	[illegible]	116.74	66.35	3.65	[illegible]	86.60	98.60	94.60	90.60	24.75	[illegible]	41.75
23	54.32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.40	[illegible]	86.73	98.73	[illegible]	90.73	[illegible]	[illegible]	[illegible]
24	[illegible]	55.77	55.89	55.80	[illegible]	[illegible]	[illegible]	[illegible]	86.50	93.50	100.50	[illegible]	90.83	[illegible]	107.50	46.05
25	59.03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	59.91	[illegible]	[illegible]	[illegible]	98.25	95.25	[illegible]	[illegible]	107.25	[illegible]
26	61.58	61.65	[illegible]	[illegible]	[illegible]	120.50	[illegible]	[illegible]	[illegible]	[illegible]	97.25	101.25	92.17	[illegible]	107.75	[illegible]
27	[illegible]	[illegible]	61.38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85.18	100.18	[illegible]	[illegible]	34.28	[illegible]	50.03
28	60.18	60.09	60.20	60.29	60.19	117.09	[illegible]	[illegible]	[illegible]	86.03	101.03	97.03	91.36	34.46	107.03	50.13
29	60.54	60.48	60.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.93	96.93	92.68	36.00	106.93	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100.93	96.93	92.65	[illegible]	106.85	51.51
31	[illegible]	62.22	[illegible]	62.32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	106.83	51.59
Feb.																
1	63.65	[illegible]	63.83	[illegible]	[illegible]	117.43	[illegible]	1.55	84.80	84.80	101.80	95.80	92.55	38.80	106.80	53.11
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	92.40	39.88	[illegible]	54.30
3	65.08	65.00	[illegible]	64.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	96.86	[illegible]	[illegible]	106.86	[illegible]
4	[illegible]	[illegible]	64.90	65.00	[illegible]	[illegible]	[illegible]	0.25	80.00	85.00	102.00	96.00	[illegible]	[illegible]	107.00	[illegible]
5	[illegible]	[illegible]	[illegible]	66.02	[illegible]	[illegible]	[illegible]	0.70	80.03	83.03	101.03	97.03	92.11	40.69	107.03	55.61
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	107.10	56.78
7	67.80	67.87	67.50	[illegible]	[illegible]	[illegible]	[illegible]	0.15	[illegible]	85.10	[illegible]	98.10	92.52	[illegible]	107.10	56.96
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.46	[illegible]	[illegible]	102.10	[illegible]	[illegible]	42.67	[illegible]	[illegible]
9	67.80	67.93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	103.10	97.10	[illegible]	42.84	107.10	[illegible]
10	[illegible]	69.73	[illegible]	[illegible]	[illegible]	[illegible]	48.81	[illegible]	[illegible]	[illegible]	[illegible]	96.02	93.60	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48.48	0.40	[illegible]	83.00	102.00	97.00	[illegible]	[illegible]	[illegible]	[illegible]
12	68.85	68.93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81.12	[illegible]	102.12	[illegible]	[illegible]	44.41	[illegible]	[illegible]
13	[illegible]	68.65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81.30	84.30	101.30	98.30	[illegible]	[illegible]	107.30	[illegible]
14	[illegible]	[illegible]	70.04	[illegible]	69.98	[illegible]	47.04	[illegible]	[illegible]	84.30	102.30	97.30	[illegible]	[illegible]	107.30	[illegible]
15	[illegible]	69.43	69.53	[illegible]	[illegible]	[illegible]	47.00	[illegible]	[illegible]	82.30	101.30	97.30	[illegible]	[illegible]	107.30	60.30
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	46.98	0.02	81.30	[illegible]	102.30	96.30	92.80	[illegible]	107.30	[illegible]
17	70.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81.30	[illegible]	102.30	96.30	92.80	46.02	107.50	[illegible]
18	70.37	70.31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.35	—		—			—	107.50	61.07

Date	Weight. Caisson.	Crib.	Masonry.	Sand.	Water.	Total.	Air Pressure. Indicated.	Calculated.	Reaction due to Air Pressure.	Net Weight.	Surface in Contact.	Average Friction per Square Foot.	Remarks.
1887 Jan.	Tons.		Tons.	Tons.	Tons.	Tons.			Tons.	Tons.	Sq. Ft.	Lbs.	Caisson suspended on screws December 29, 1886, in the P. M.
5	225		—	—	—	225	—		—	225	—	—	Commenced lowering at 7 A. M. Commenced concreting at 2 P. M
6	[illegible]				122	103	—			103	—	—	— [illegible]
7	436				295	141	-			[illegible]			
8	[illegible]				354	[illegible]	-			[illegible]			— [illegible]
9	[illegible]				416	205	[illegible]			205		—	Air pressure put on at 10 A. M
10	[illegible]				16	[illegible]	10.00	7.00	[illegible]	11			
11	905		—		17	923	10.00	7.31	819	80	95	1810	Screws and false-work removed.
12	920		—		24	44	0.25	7.45	835	85	189	899	First stone laid 9 A. M
13	920		115		28	[illegible]	10.25	7.88	883	180	298	[illegible]	
14	920		269		41	1230	12.00	[illegible]	[illegible]	307	356	[illegible]	Started sand-pump 7.20 A. M
15	920		510	6	129	1565	13.50	[illegible]	1145	[illegible]	[illegible]	684	
16	920		700	12	197	[illegible]	14.00	11.47	[illegible]	[illegible]	825	[illegible]	High wind
17	920		700	22	245	[illegible]	15.00	12.40	1359	[illegible]	2204	[illegible]	
18	920		94	[illegible]	306	2196	[illegible]	13.53	1516	680	2610	[illegible]	
19	920		1112	43	354	2479	17.00	[illegible]	[illegible]	852	3115	547	Very cold weather. Masons not at work in P. M
20	920		1273	104	433	2739	18.50	16.39	1836	[illegible]	3399	525	Very cold weather. Masons not at work in P. M.
21	920		1375	135	413	[illegible]	19.50	16.35	[illegible]	[illegible]	[illegible]	[illegible]	
22	[illegible]		1587	[illegible]	432	3191	[illegible]	17.86	2001	[illegible]	[illegible]	604	Struck gravel and clay
23	920		1790	[illegible]	445	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	631	
24	920		[illegible]	478	439	[illegible]	23.00	19.94	[illegible]	1493	4596	619	
25	920		2078	[illegible]	449	3975	23.00	20.50	[illegible]	[illegible]	[illegible]	[illegible]	Masonry 9.18 ft. above water surface. Moved derrick-boat to Pier D.
26	920		2078	651	405	[illegible]	24.00	20.91	[illegible]	[illegible]	5080	673	
27	920	No Crib	2078	690	427	[illegible]	24.00	21.66	[illegible]	1607	5213	651	
28	920		2078	707	424	[illegible]	24.00	21.71	2432	[illegible]	[illegible]	[illegible]	
29	920		2078	778	388	4164	24.00	21.76	2438	1776	[illegible]	636	
30	920		2078	841	361	4200	25.00	22.30	[illegible]	[illegible]	[illegible]	608	Caisson settled for the first time by relieving pressure at 5 A. M
31	920		2078	860	381	4239	25.00	22.34	2503	1736	[illegible]	615	Caisson settled at 5 P. M
Feb.													
1	920		2078	912	395	4305	25.50	23.00	2577	1728	5784	598	Caisson settled at 6.25 P. M
2	920		2078	960	402	4360	26.00	23.51	2634	1726	5911	584	
3	920		2078	957	409	4364	26.00	23.59	2643	1721	5901	583	
4	920		2078	987	404	4389	26.00	23.76	2662	1727	5982	577	Derrick-boat brought back; masons at work again
5	920		2174	997	418	4509	28.00	24.08	2698	1811	6011	602	Caisson settled at 11 A. M
6	920		2263	1059	[illegible]	[illegible]	28.00	[illegible]	2754	[illegible]	6166	618	Caisson settling gradually without relieving pressure
7	920		2401	[illegible]	413	4813	28.00	[illegible]	2763	2050	6208	660	" " " " "
8	920		2442	1003	[illegible]	4864	28.00	24.56	2755	[illegible]	6254	665	" " " " "
9	920		2442	1101	[illegible]	4884	28.00	[illegible]	[illegible]	2087	6276	665	" " " " "
10	920		2442	1130	383	4941	28.50	[illegible]	2873	2118	6514	650	" " " " "
11	920		2442	1198	392	4953	28.50	25.37	2842	2110	6570	647	" " "
12	920		2442	[illegible]	413	4957	28.00	25.4	2854	2095	6469	648	" " " "
13	920		2442	[illegible]	411	[illegible]	28.00	25.68	[illegible]	2103	6539	643	Caisson settled at 5 P. M
14	920		2442	1305	353	5050	29.50	26.09	2973	[illegible]	[illegible]	[illegible]	
15	920		2442	1303	385	5050	30.00	26.11	2925	[illegible]	[illegible]	627	
16	920		2442	[illegible]	[illegible]	5026	29.50	26.12	2926	2100	6041	659	
17	920		2442	[illegible]	424	5041	29.50	26.29	[illegible]	[illegible]	6666	628	Cutting rock under cutting-edge. Caisson landed on bed-rock at 5 P. M. Settled 0.10 ft. by relieving pressure until cutting-edge began to buckle
18					—	—	29.50	26.44	2962				

APPENDIX D.

TIME, COST, AND MATERIALS USED IN FOUNDATIONS.

PIER A.

Date	Prog. Foreman Days	Prog. Foreman Amount	Night Foreman Days	Night Foreman Amount	Sub-Foreman Days	Sub-Foreman Amount	Lock Tenders Days	Lock Tenders Amount	Pressure Men Days	Pressure Men Amount	Coffee House Men Days	Coffee House Men Amount	Coffee Lbs	Coffee Amount	Sugar Lbs	Sugar Amount	Candles Number	Candles Amount	Incandescent Lamps Number	Incandescent Lamps Amount
1885 Dec 15	1	$6 00	1	$3 23	3	$9 00	2	$4 50	26 5	$59 60	2	$3 75	3	$0 36	4	$0 30	22	$0 50	—	—
16	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	3½	40	4½	34	16	36	—	—
17	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	2¾	33	4½	33	27	61	—	—
18	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	2¾	33	8	60	24	54	—	—
19	1	6 00	1	3 23	3	9 00	2	4 50	26 0	58 50	2	3 75	4	48	4	30	5	11	—	—
20	1	6 00	1	3 23	3	9 00	2	4 50	26 0	58 50	2	3 75	2	24	4½	34	4	09	—	—
21	1	6 00	1	3 23	3	9 00	2	4 50	26 0	58 50	2	3 75	2¼	27	4½	34	13	29	—	—
22	1	6 00	1	3 23	3	9 00	2	4 50	26 0	58 50	2	3 75	2¾	33	4½	34	8	18	—	—
23	1	6 00	1	3 23	3	9 00	2	4 50	26 0	58 50	2	3 75	2¾	33	4¾	36	8	18	—	—
24	1	6 00	1	3 23	3	9 00	2	4 50	26 0	58 50	2	3 75	3	36	4½	34	12	27	—	—
25	1	6 00	1	3 23	3	9 00	2	4 50	26 0	58 50	2	3 75	2½	30	4½	33	5	11	—	—
26	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	2¾	33	4½	34	10	23	—	—
27	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	2½	30	4½	34	9	20	—	—
28	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	3	36	4½	34	11	25	—	—
29	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	2¾	33	4½	33	14	31	—	—
30	1	6 00	1	3 23	3	9 00	2	4 50	27 0	60 75	2	3 75	2¾	33	4½	34	2	04	—	—
31	1	6 00	1	3 22	3	9 00	2	4 50	27 0	60 75	2	3 75	2	24	4	30	9	20	—	—
1886 Jan 1	1	6 00	1	4 00	3	9 00	2	4 50	25 0	56 25	2	3 75	4	48	6	45	13	29	—	—
2	1	6 00	1	4 00	3	9 00	2	4 50	26 0	58 50	2	3 75	5	1 15	6	45	2	04	—	—
3	1	6 00	1	4 00	3	9 00	2	4 50	[illegible]	[illegible]	2	3 75	4	92	6	45	2	05	—	—
4	1	6 00	1	4 00	3	9 00	2	4 50	26 0	58 50	2	3 75	2¾	63	4	30	15	34	—	—
5	1	6 00	1	4 00	3	9 00	2	4 50	15 0	33 75	2	3 75	2	41	4	30	5	11	—	—
6	1	6 00	1	4 00	3	9 00	2	4 50	15 0	33 75	2	3 75	2	46	4	30	4	09	—	—
7	1	6 00	1	4 00	3	9 00	2	4 50	21 0	47 25	2	3 75	2	40	4	30	8	18	—	—
8	1	6 00	1	4 00	3	9 00	2	4 50	17 0	38 25	2	3 75	2	46	4	30	4	09	—	—
9	1	6 00	1	4 00	3	9 00	2	4 50	15 0	33 75	2	3 75	2	46	4	30	4	09	—	—
10	1	6 00	1	4 00	3	9 00	2	4 50	13 0	29 25	2	3 75	2	23	4	30	—	—	—	—
11	1	6 00	1	4 00	3	9 00	2	4 50	17 0	[illegible]	2	3 75	2	46	[illegible]	15	—	—	—	—
12	1	6 00	1	4 00	3	9 00	2	5 00	17 0	42 50	2	3 75	4	72	5	38	[illegible]	[illegible]	—	—
13	1	6 00	1	4 00	4	12 00	2	5 00	31 0	[illegible]	2	3 75	3	69	6	45	6	13	—	—
14	1	6 00	1	4 00	4	12 00	2	5 00	31 0	77 50	2	3 75	4	92	7	52	6	14	—	—
15	1	6 00	1	4 00	5	15 00	2	5 00	[illegible]	[illegible]	2	3 75	4	92	7	53	3	07	—	—
16	1	6 00	1	4 00	6	19 50	2	5 00	47 5	[illegible]	2	3 75	5	1 15	4½	33	5	11	—	—
17	1	6 00	1	4 00	6	19 50	2	5 00	53 0	132 50	2	3 75	4½	1 05	9	67	3	06	—	—
18	1	6 00	1	4 00	6	19 50	2	5 00	48 5	121 25	2	3 75	[illegible]	[illegible]	5	36	[illegible]	[illegible]	—	—
19	1	6 00	1	4 00	6	19 50	2	5 00	50 0	125 00	2	3 75	4½	63	9	68	[illegible]	[illegible]	—	—
20	1	6 00	1	4 00	6	19 50	2	5 00	51 0	127 50	2	3 75	4	56	5	37	3	07	—	—
21	1	6 00	1	4 00	6	19 50	2	5 00	50 0	125 00	2	3 75	4	56	4	30	3	07	—	—
22	1	6 00	1	4 00	6	19 50	2	5 00	47 0	117 50	2	3 75	3	42	5	38	5	12	—	—
23	1	6 00	1	4 00	6	19 50	2	5 00	49 0	122 50	2	3 75	4	50	5	37	3	07	—	—
24	1	6 00	1	4 00	6	19 50	2	5 00	49 5	123 75	2	3 75	3	42	10	75	8	18	—	—
25	1	6 00	1	4 00	6	19 50	2	5 00	52 0	130 00	2	3 75	3	42	[illegible]	[illegible]	2	05	—	—
26	1	6 00	1	4 00	6	19 50	2	5 00	52 0	130 00	2	3 75	[illegible]	[illegible]	[illegible]	[illegible]	5	11	—	—
27	1	6 00	1	4 00	6	19 50	2	5 00	52 0	130 00	2	3 75	4	56	10	75	5	11	—	—
28	1	6 00	1	4 00	6	19 50	2	5 00	52 5	131 25	2	3 75	4	56	9	67	4	09	—	—
29	1	6 00	1	4 00	6	19 50	2	5 00	52 5	131 25	2	3 75	4	56	10	75	9	20	—	—
30	1	6 00	1	4 00	6	19 50	2	5 00	56 0	140 00	2	3 75	5	[illegible]	10	75	2	03	—	—
31	1	6 00	1	4 00	6	19 50	2	5 00	52 0	130 00	2	3 75	3	42	5	37	—	—	—	—
Feb 1	1	6 00	1	4 00	6	19 50	2	5 00	52 0	130 00	2	3 75	4	56	9	68	—	—	—	—
2	1	6 00	1	4 00	6	19 50	2	5 00	53 0	132 50	2	3 75	4	56	10	75	3	07	—	—
3	1	6 00	1	4 00	6	19 50	2	5 00	53 0	132 50	2	3 75	4	[illegible]	4	30	3	05	—	—
4	1	6 00	1	4 00	6	19 50	2	5 00	53 0	132 50	2	3 75	4	[illegible]	9	67	[illegible]	13	—	—
5	1	6 00	1	4 00	6	19 50	2	5 00	53 0	132 50	2	3 75	4	[illegible]	—	—	—	—	—	—
6	1	6 00	1	00	6	19 50	—	—	52 5	131 25	2	3 75	—	—	—	—	—	—	25	$21 25
Totals		32 00		[illegible]		733 00		251 00		4620.85		207 50		[illegible]		[illegible]		8.03		21 25

Date	Red Lead Lbs	Red Lead Amount	Wicks Balls	Wicks Amount	Coal for Heating 100-lb Boxes	Coal for Heating Amount	Linseed Oil Pints	Linseed Oil Amount	Master Mechanic Days	Master Mechanic Amount	Electrician Days	Electrician Amount	Engineers at Compressors Days	Engineers at Compressors Amount	Engineers at Pumps Days	Engineers at Pumps Amount	Firemen Days	Firemen Amount	Coal for Boilers Tons	Coal for Boilers Amount
1885 Dec 15	50	$3 63	10	$0 [illegible]	3	$0 54	4	$0 25	1	$4 00	—	—	2 4	$6 60	1 2	$[illegible] 80	5 0	$11 25	6	$21 60
16	—	—	—	—	3	54	—	—	1	4 00	—	—	2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
17	—	—	—	—	3	54	—	—	1	4 00	—	—	2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
18	—	—	—	—	3	54	—	—	1	4 00			2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
19	—	—	—	—	3	54	—	—	1	4 00			2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
20	—	—	—	—	3	54	—	—	1	4 00	0.5	$1 25	2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
21	—	—	—	—	3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
22	—	—	—	—	3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
23	—	—	—	—	3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
24	—	—	—	—	3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
25	—	—	—	—	3	54			1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
26	—	—	—	—	3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
27	—	—	—	—	3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
28		—		—	3	54			1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
29	—		—		3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
30		—			3	54	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
31	50	3 63	10	25	3	54	4	25	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	22 50
1886 Jan 1	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6¼	23 40
2	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	8	28 80
3	—	—	—	—	4	72	—	—	1	4 00	0 7	1 75	2 4	6 60	1 2	2 40	4 8	9 00	5¼	19 70
4	—	—	—	—	4	72	—	—	1	4 00	—	—	2 4	6 60	1 2	2 40	3 7	6 6[illegible]	8	28 80
5	—	—	—	—	4	72			1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	6	21 60
6	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	4 8	9 00	4	14 40
7	—	—			4	72			1	4 00	1	2 50	2 4	6 60	—	—	4 8	9 00	4	14 40
8	—	—	—	—	4	72			1	4 00	1	2 50	2 4	6 60	—	—	4 8	9 00	4	14 40
9	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	—	—	4 8	9 00	3½	12 60
10	50	3 63	10	24	4	72	4	25	1	4 00	1	2 50	2 4	6 60	—	—	4 8	9 00	4	14 40
11	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60			4 8	9 00	4½	16 20
12	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	[illegible]	1 0	5 50	4 8	9 00	8	28 80
13	—	—	—	—	4	72			1	4 00	1	2 50	2 4	[illegible]	1 0	5 50	4 8	9 00	8	28 80
14		—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	2 0	6 05	4 8	9 00	8	28 80
15	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	2 0	5 50	4 8	9 00	9	32 40
16				—	4	72			1	4 00	1	2 50	2 4	6 60	2 0	5 50	4 8	9 00	9	32 40
17				—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	2 0	5 50	4 8	9 00	8	28 80
18	—	—			4	72	—		1	4 00	1	2 50	2 4	6 00	2 2	5 15	4 8	9 00	8	28 80
19			—	—	4	72			1	4 00	1	2 50	2 4	6 00	2 0	5 50	4 8	9 00	8	28 80
20				—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	1 2	3 30	4 6	8 10	8¼	30 60
21			—	—	4	72		—	1	4 00	1	2 50	2 4	6 60	1 2	3 30	5 8	11 00	10	36 00
22					4	72	—	—	1	4 00	1	2 50	2 4	6 60	2	3 30	5 8	11 00	14	50 40
23	—	—		—	4	72			1	4 00	1	2 50	2 4	6 60	2	3 30	5 8	11 00	3	[illegible]
24				—	4	72			1	4 00	1	2 50	2 4	6 60	—	—	[illegible]	[illegible]	[illegible]	[illegible]
25	—	—			4	72	—	—	1	4 00	1	2 50	2 4	6 60	2 4	5 70	[illegible]	[illegible]	11	[illegible]
26		—	—	—	4	72			1	4 00	1	2 50	2 4	6 00	2 4	5 70	4 0	7 60	9	32 40
27					4	72		—	1	4 00	1	2 50	2 4	6 60	2 4	5 70	3	6 00	9	32 40
28					4	72	—	—	1	4 00	1	2 50	2 4	6 60	2 4	5 70	[illegible]	[illegible]	8	28 80
29				—	4	72			1	4 00	1	2 50	2 4	6 60	2 4	5 70	4 6	[illegible]	[illegible]	30.60
30	50	3 63	10	25	4	72	4	25	1	4 00	1	2 50	2 4	6 60	2 4	5 70	4 8	9 00	9	32 40
31	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	2 4	5 70	4 8	9 00	8¼	29 70
Feb 1		—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	1 0	2 00	4 8	9 00	8	28 80
2					4	72			1	4 00	1	2 50	2 4	6 60	1 0	2 00	3 6	6 60	6	21 60
3	—	—	—	—	4	72	—	—	1	4 00	1	2 50	2 4	6 60	1 0	2 00	3 6	6 60	5	18 00
4					4	72		—	1	4 00	1	2 50	2 4	6 60	1 2	2 40	3 6	6 60	7	25 20
5		—		—		—		—	1	4 00	1	2 50	2	6 60	1 0	2 00	5 3	9.87	5	18 00
6		—		—		—	—	—	—	—		—		—		—	—	—	—	—
Totals		14 52		0.98		31 78		1 00		212.00		115 50		349.80		115 30		460.77		13[illegible]6.10

Date	Black Oil Pints	Black Oil Amount	Lard Oil Pints	Lard Oil Amount	Tallow Lbs	Tallow Amount	Waste Lbs	Waste Amount	Coal Oil Pints	Coal Oil Amount	Totals for each Day	Feet sunk in 24 Hours	Material	Worthington Pump Hours run	Worthington Pump Rev. per Min.	Worthington Pump Water Gauge	Compressors Rev. per Min.	Compressors Air Gauge	Remarks
1885 Dec 15	8	$0.47	8	$0 50	3	$0.18	½	$0 03			$141 33	0.16	Silt and sand	No Record	No Record	No Record	10		Air pressure put on at 7 A.M.
16	—	—	—	—	3	15	½	03			132 59	0.01					10	1.00	
17	—	—	—	—	2	12	½	03	—	—	132 79	0 22					10	1 00	
18	8	47	8	50	2	12	½	03	—	—	133 90	1 51					10	1 50	
19	—	—	—	—	2	12	½	03			130 15	2 24					10	1 25	
20	—	—	—	—	2	12	½	03	—	—	131 19	0 84					10	3 00	
21	—	—	—	—	2	12	½	03	—	—	134 91	2 35					10	2 75	
22	8	47	8	50	2	12	½	03			135 83	1 70					10	3 50	
23	—	—	—	—	2	12	½	03	—	—	135 79	2 35					10	4 75	
24			—	—	2	12	½	03	—	—	133 63	2 71					10	3 00	
25	—	—	—	—	2	12	½	03			133 10	11					10	8 00	
26	8	47	8	50	2	12	½	03	—	—	136 79	2 73					11	9 00	
27			—	—	2	12	½	03	—		135 75	2 49					11	9 50	
28	—	—	—	—	3	18	½	03		—	135.93	3.26					11	11 00	Ice broke in river
29	40	2 44	[illegible]	50	12	[illegible]	½	03			139 06	1 63					11	12 50	
30			—	—	12	[illegible]	½	03	—		126.87	2 03					[illegible]	14 00	
31	16	94	8	.50	8	48	1	06	—	—	141 61	2.80					27	14 50	
1886 Jan 1	16	94		—	8	48	½	03			134 70	2.80					51	15 00	
2	16	93	—	—	8	48	½	03	—		[illegible]	3 13					45	15 25	
3	8	46	—	—	16	96	½	03	—	—	[illegible]	[illegible]					18	15 50	
4	24	1 40	—	—	8	48	½	03		—	135.05	2 04					16	1 00	Ran out of coal Tracks blocked with snow blizzard
5	8	94	—	—	8	48	½	03			101 4[illegible]	0 00					22	1 00	
6	16	94	—	—	8	48	½	03	—	—	[illegible]	[illegible]					22	10 00	
7	8	[illegible]	—	—	8	48	½	03		—	113 61	0 00					20	11 25	
8	16	93	—	—	8	48	½	03			[illegible]	0.00					20	—	Blizzard no work done, — only pressure kept up in caisson
9	8	47	—	—	8	48	½	03			[illegible]	[illegible]					20	18 25	
10	8	4[illegible]	—	—	8	48	½	03	—	—	99 35	[illegible] 00					20	15 50	
11	2	11	—	—	12	[illegible]	½	03			94 30	0 00					20	16 50	
12	2	12	—	—	12	[illegible]	½	03	—		[illegible]	0 00					—	17 75	
13	2	11	—	—	4	24	½	03	—	—	[illegible]	[illegible]					[illegible]	16 25	
14	2	12	—	—	4	24	½	03			[illegible]	[illegible]						20 50	First course of masonry laid
15	4	23	8	50	4	24	½	03	8	12	[illegible]	[illegible]	Mud				[illegible]	26 50	
16	4	21	—	—	4	24	½	03	—		[illegible]	0 09					38	23 00	
17	8	47	—	—	8	[illegible]	½	03		—	230 3[illegible]	[illegible]					42	23 00	Both compressors running from 2 P.M. to 8 P.M., at 25 revolutions per minute
18	16	94	4	25	4	24	½	.03	8	13	[illegible] 49	0 00					45	24 00	
19	8	46	—	—	8	48	½	.03	—		[illegible]	0 00					45	[illegible] 00	
20	4	23	—	—	8	48	½	03		—	[illegible]	0 00					48	24 00	One compressor, 12 hrs., two compressors, 12 hrs., at 28 revolutions per minute each
21	4	24	8	50	8	48	½	03	—		[illegible]	[illegible]	Sand and mud				40	25 55	Two compressors
22	8	[illegible]	—	—	8	48	½	03	8	12	[illegible]	[illegible] 00					38	25 00	" "
23	8	94	—	—	8	[illegible]	½	03		—	[illegible]	[illegible]					40	24 00	" "
24	8	47	—	—	8	[illegible]	½	03			[illegible]	0 00					[illegible]	[illegible]	" "
25	8	[illegible]			8	[illegible]	½	03	—		241 [illegible]	[illegible]					51	26 00	" "
26	16	93	—	—	8	48	½	03		—	[illegible]	0 00					52	26 00	" "
27	32	1.87	—		8	[illegible]	½	03	—		[illegible]	[illegible]					[illegible]	2[illegible] 50	" "
28	16	94			[illegible]	[illegible]	½	03	—	—	[illegible]	[illegible]					[illegible]	27 00	" "
29	8	46			[illegible]	[illegible]	½	03		—	[illegible]	1 4[illegible]					[illegible]	[illegible] 00	" "
30	16	94	—	—	16	96	½	03			240.7[illegible]	0.00					[illegible]	[illegible] 00	" "
31	32	1 8[illegible]		—	16	[illegible]	½	03	—		230.12	0.58					35	[illegible] 00	Cutting edge on bed-rock at 7 P.M.
Feb 1	16	93	8	50	8	48	½	03	—		225 0[illegible]						35		
2	40	2 44		—	8	48	½	.03	—	—	216 10	—					35		
3	24	1 41	—		8	[illegible]	1	06		—	214 01	—					35		
4	32	1.87	—	—	8	48	1	06	—		222 54						35		
5	—				—		2	12	—	—	214 40						30		
6		—	—		—	—	2	12		—	159.6[illegible]								
											21 25								
Totals		32 50		4 75		20.10		1.89		0.37	9219 40								

Other expenses charged to Sinking . . . $870 91

$10,090.37

TIME, COST, AND MATERIALS USED IN FOUNDATIONS.

PIER B.

Date	Foreman Days	Foreman Amount	Night Foreman Days	Night Foreman Amount	Sub-Foreman Days	Sub-Foreman Amount	Lock Tenders Days	Lock Tenders Amount	Pressure-Men Days	Pressure-Men Amount	Cement-Mixers Days	Cement-Mixers Amount	Coffee lbs	Coffee Amount	Sugar lbs	Sugar Amount	Candles Number	Candles Amount
1886 Feb 6						—	—	—	—	-	—	—	3	$0.42	3	$0.21	14	$0.31
7	1	$6.00	1	$4.00	3	$9.00	2	$4.50	27.0	$60.75	2	$3.75	3	42	9	.64	24	54
8	1	6.00	1	4.00	4	12.00	2	4.50	29.0	65.25	2	3.75	3	42	4	28	23	52
9	1	6.00	1	4.00	4	12.00	2	4.50	39.5	88.88	2	3.75	3	42	9	.64	7	11
10	1	6.00	1	4.00	4	12.00	2	4.50	29.5	[illegible]	2	3.75	3	42	4	29	1	09
11	1	4.50	1	3.33	3	9.00	2	4.50	21.0	47.25	2	3.75	2	28	9	.64	2	05
12	1	4.50	1	3.33	3	9.00	2	4.50	13.0	29.25	2	3.75	2	28	5	35	—	—
13	1	4.50	1	3.34	3	9.00	2	4.50	15.0	33.75	2	3.75	2	28	4	28	4	09
14	1	4.50	1	3.33	3	9.00	2	4.50	24.0	54.00	2	3.75	2	28	4	29		—
15	1	4.50	1	3.33	3	9.00	2	4.50	26.0	58.50	2	3.75	3	42	5	30	—	—
16	1	4.50	1	3.34	3	9.00	2	4.50	27.0	60.75	2	3.75	3	.42	5	35	6	13
17	1	4.50	1	3.33	3	9.00	2	4.50	27.0	60.75	2	3.75	2	28	5	36		—
18	1	4.50	1	3.33	3	9.75	2	5.00	26.0	65.00	2	3.75	3	42	5	35	—	
19	1	4.50	1	3.34		13.00	2	5.00	34.0	85.00	2	3.75	4	56	9	63	—	
20	1	4.50	1	3.33	4	13.00	2	5.00	35.0	[illegible]	2	3.75	3	42	5	36	6	14
21	1	4.50	1	3.33	4	13.00	2	5.00	34.0	85.00	2	3.75	4	56	4	28		
22	1	4.50	1	3.34	4	13.00	2	5.00	37.0	92.50	2	3.75	2	28	4	27		—
23	1	4.50	1	3.33	4	13.00	2	5.00	35.0	87.50	2	3.75	4	56	5	57	2	.04
24	1	4.50	1	3.33	4	13.00	2	5.00	38.4	96.00	2	3.75	2	28	4	28		—
25	1	4.50	1	3.31	4	13.00	2	5.00	34.0	85.00	2	3.75	3	42	4	29		—
26	1	4.50	1	3.33	4	13.00	2	5.00	35.0	87.50	2	3.75	3	42	5	35		—
27	1	4.50	1	3.33	4	13.00	2	5.00	35.0	87.50	2	3.75	4	50	7	50	8	.18
28	1	4.50	1	3.34	4	13.00	2	5.00	26.4	66.00	2	3.75	2	28	6	43	—	—
Mar 1	1	4.50	1	3.33	4	13.00	2	5.00	36.0	90.00	2	3.75	3	42	6	43		-
2	1	4.50	1	3.33	4	13.00	2	5.00	35.0	87.50	2	3.75	3	42	9	.64	—	-
3	1	4.50	1	3.34	4	13.00	2	5.00	35.0	87.50	2	3.75	3	42	9	.64	2	05
4	1	4.50	1	3.33	4	13.00	2	5.00	34.0	85.00	2	3.75	4	56	6	43	—	
5	1	4.50	1	3.33	4	13.00	2	5.00	33.0	82.50	2	3.75	2	28	6	42	—	
6	1	4.50	1	3.34	5	16.25	2	5.00	35.5	[illegible]	2	3.75	4	56	9	64	-	
7	1	4.50	1	3.33	6	19.50	2	5.00	43.0	107.50	2	3.75	4	56	8	57	—	
8	1	4.50	1	3.33	6	19.50	2	5.00	43.5	108.75	2	3.75	6	84	13	92	-	
9	1	4.50	1	3.34	6	21.00	2	5.50	45.5	125.12	2	3.75	5	70	9	65	3	.07
10	1	4.50	1	3.33	6	21.00	2	5.50	45.0	123.75	2	3.75	5	70	12	.86	—	
11	1	4.50	1	3.33	6	21.00	2	5.50	56.5	155.37	2	3.75	6	84	9	64		
12	1	4.50	1	3.34	6.3	22.00	2	5.50	45.3	124.57	2	3.75	5	70	9	64	19	43
13	1	4.50	1	3.33	5.5	19.25		—	28.6	78.65	1	2.00	2	.28	3	22	8	15
		163.50		119.33		472.25		166.50		2894.95		129.50		16.38		16.73		2.90

Date	Incandescent Lamps Number	Incandescent Lamps Amount	Red Lead lbs	Red Lead Amount	Wick Balls	Wick Amount	Coal for Heating 100 lb Boxes	Coal for Heating Amount	Linseed Oil Pints	Linseed Oil Amount	Master Mechanic Days	Master Mechanic Amount	Electrician Days	Electrician Amount	Engineers at Compressors Days	Engineers at Compressors Amount	Engineers at Pumps Days	Engineers at Pumps Amount	Firemen Days	Firemen Amount
1886 Feb 6	—	—	25	$1.81	10	$0.[illegible]	4	$0.55	8	$0.50	1	$4.00	1	$2.50	2.4	$6.60	1.8	$3.60	4.8	$9.00
7	—	—	—			—	4	55			1	4.00	1	2.50	2.4	6.60	1.2	2.40	1.8	[illegible]
8	—	—	—			—	4	55	—	—	1	4.00	1	2.50	2.4	6.60	1.2	2.40	7.2	13.50
9	—	—	—			—	4	55	—	—	1	4.00	1	2.50	2.4	6.60	1.2	2.40	6.0	11.10
10	—	—	—			—	4	54			1	4.00	1	2.50	2.4	6.60	1.2	2.40	6.0	11.10
11		—	—	—		—	4	55	—		1	4.00	1	2.50	2.4	6.60	1.2	2.40	6.0	11.10
12		—	—	—		—	4	55	—		1	4.00	1	2.50	2.4	6.60	1.2	2.40	6.0	11.10
13			25	1.52		—	4	55	—		1	4.00	1	2.50	2.4	6.00	1.2	2.40	6.0	11.10
14			—	—		—	4	55			1	4.00	1	2.50	2.4	6.60	1.2	2.40	4.8	[illegible]
15	—				—		4	5[illegible]			1	4.00	1	2.50	2.4	6.60	1.2	2.40	6.0	11.10
16	—	—	—	—	-		4	55		—	1	4.00	1	2.50	2.4	6.60	1.2	2.40	6.0	11.10
17	—	—	-	—		—	4	.55	—		1	4.00	1	2.50	2.4	6.60	1.2	2.40	6.0	11.10
18	—	—		—		—	4	55	—		1	4.00	1	2.50	2.4	6.60	3.2	6.40	[illegible]	7.05
19	—	—		—		—	4	55	—		1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
20	—		25	1.51	5	.13	4	54	8	50	1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
21	—	—				—	4	55	—		1	4.00	1	2.50	2.4	6.00	2.4	4.80	4.8	9.00
22	—	—			—	—	4	55	—		1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
23	-	—			—	—	4	55			1	4.00	1	2.50	2.4	6.60	2	4.80	4.8	9.00
24	—	—			—	—	4	.55			1	4.00	1	2.50	2.4	6.60	2.1	4.80	4.8	9.00
25	—	—			—	—	4	54		—	1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
26	—	—	—		—	-	3	41		—	1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	[illegible]
27	—	—	25	1.82	—	—	3	41	-	—	1	4.00	1	2.50	2.4	6.60	3	7.80	4.8	[illegible]
28	—	—	—	—	—	—	3	41	-	—	1	4.00	1	50	2.4	6.60	2.4	4.80	4.8	9.00
Mar 1	—	—	—	-	—	-	3	41	—	—	1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
2	—	-	—		—		3	41	-		1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
3	—	-	50	3.63	5	.13	3	41	8	50	1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
4	—	—					3	.41	—		1	4.00	1	2.50	2.4	6.00	2.4	4.80	4.8	9.00
5	—	—					3	41			1	4.00	1	2.50	2.4	6.00	2.4	4.80	4.8	7.00
6	—	—					3	41			1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
7	—	—				—	3	42			1	4.00	1½	3.75	2.4	6.60	2.4	4.80	1.8	9.00
8	—	—	25	1.81	—	—	3	41	—		1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
9	—	—	—		—	—	3	41	—		1	4.00	1	2.50	2.4	6.60	2.4	4.80	4.8	9.00
10	—	—	—	—	—	—	3	41	—		1	4.00	1	2.50	2.4	6.60	[illegible]	5.70	4.8	9.00
11	-	—	-	—	—	-	3	41	—		1	4.00	1	2.50	2.4	6.00	1.2	2.40	4.8	9.00
12	—	—	-	—	-	—	3	41	—	—	1	4.00	1	2.50	2.4	6.60	—	—	4.8	9.00
13	—	—	—	—	-	-	3	41			—	—	—				—	—	-	
	25	$21.25	—	—		—	-	—	—	—			—	—			—		—	—
		21.25		12.70		0.49		17.53		1.50		140.00		88.75		231.00		138.20		334.65

Date	Coal for Boilers Tons	Coal for Boilers Amount	Black Oil lbs	Black Oil Amount	Lard Oil Pints	Lard Oil Amount	Tallow lbs	Tallow Amount	Waste lbs	Waste Amount	Coal Oil Pints	Coal Oil Amount	Total for each Day	Feet sunk in 24 Hours	Material	Working Pump Hours	Revol. per Min.	Water Gauge	Compressors Revol. per Min.	Air Gauge	Remarks
1886 Feb 6	4	$11.00	34	$1.40	8	$0.50	8	$0.48	1	$0.02	2	$0.03	$431.[illegible]	2.43	Silt	14			25	5.00	Air pressure put on at 4 P. M. Sand-pump started at 5 P. M.
7	4	11.00	8	47	—		8	48	½	03		—	13[illegible]	3.5[illegible]		24			14	5.00	
8	4½	[illegible]	8	4[illegible]	-		8	45	½	02		—	139.3[illegible]	3.2[illegible]	"	24			16	5.[illegible]	
9	5	13.[illegible]	8	47	—		8	45	½	03			162.[illegible]	3.19	"	24			20	6.[illegible]	
10	5	13.[illegible]5	8	47	—		8	45	½	02		—	139.[illegible]8	2.04	"	7			24	[illegible].00	Waiting for first course of masonry
11	3	8.25	8	.4[illegible]	—		8	45	½	03	—		109.[illegible]	0.[illegible]9		0			20	10.50	Waiting for masonry
12	[illegible]	5.50	4	23			8	45	½	02	—		[illegible]	0.[illegible]5	"	0			18	10.50	Waiting for masonry First course laid
13	6½	[illegible]	8	17	-		8	45		03			[illegible]	[illegible]		15			[illegible]	[illegible]	
14		19.[illegible]5	8	4			8	48	½	02	2	03	124.05	[illegible]	Fine sand	[illegible]			[illegible]	13.00	
15		16.50	8	4[illegible]			8	.48	1	05	2	03	12[illegible].03	2.06	Fine sand Some brush and logs	10			[illegible]	[illegible]	Waiting for masonry
16	6½	17.88	8	.47	8	.50	8	48	½	03		—	133.2[illegible]	3.2[illegible]	Fine sand A[illegible] the clay	15½			34	[illegible]	
17	-	19.25	8	46	—	—	16	96	½	.02		—	134.3[illegible]	1.[illegible]	"	24			[illegible]	[illegible].00	
18	[illegible]	16.50	8	47	—		8	48	½	03		—	137.58	3.3[illegible]	"	24			20	[illegible].00	
19	7	1[illegible].25	8	4	—	—	8	48	½	.03		-	163.40	2.10	Sand and clay	24			[illegible]	26.00	First settle of pier by relieving pressure at 6.30 A. M. High wind
20	8½	[illegible]	8	4	—		8	45	½	.03			17[illegible]	[illegible]	"	23½			[illegible]	[illegible]6.00	
21	8	[illegible]2.00	8	47			8	48	½	.02	-	—	165.84	[illegible].88	"	0			24	[illegible]	Waiting for masonry
22	7	19.25	32	1.87			16	96	½	.03	-	—	17[illegible]	4.53	Fine sand	[illegible]	No Record	No Record	30	[illegible]00	
23	7½	[illegible]0.62	1	[illegible]			8	45	½	02	-	—	[illegible]	0.00	" "	[illegible]			48	[illegible]	
24	6½	[illegible]	24	1.11	8	.50	8	45	½	03	2	.03	173.61	[illegible]97	" "	15			[illegible]	[illegible]00	
25	6	16.50	16	93		—	8	.48	½	02	-		160.[illegible]	0.00	" "	0			30	[illegible]	Waiting for masonry
26	4½	[illegible]	16	.94		—	8	45	½	03	-		15[illegible]	[illegible]	"				[illegible]	33.00	" "
27	4½	[illegible]	24	1.40		—	8	45	½	02			[illegible]	0.00	"	[illegible]			[illegible]	35.[illegible]0	
28	5	13.75	8	40		—	8	45	½	03	-		138.33	0.00		[illegible]			28	35.50	
Mar 1	5½	[illegible]5.12	32	1.8[illegible]	8	50	8	45	½	02			[illegible]	3.[illegible]	Fine sand	16			30	38.00	
2	4½	12.38	16	94			8	45	½	03			159.28	0.00	" "	7			42	38.00	
3	6	16.50	8	4	-		8	45	½	02	-		[illegible]	2.26	" "	12			45	[illegible]	
4	8	22.00	32	1.88	—		8	.48	½	03			[illegible]7.27	0.9[illegible]	" "	12			72	40.00	
5	8	[illegible]2.00	8	47	—		8	48	½	02			163.06	[illegible].10	" "	14			[illegible]2	40.50	
6	8	22.00	16	93	—		8	48	½	03			173.54	1.4[illegible]	"	23			[illegible]2	40.50	
7	7½	[illegible]2.63	8	47	—		8	48	½	.02			196.88	0.60	" "	[illegible]			40	40.50	Cutting edge on bed-rock at 4 P. M.
8	7	19.25	8	4	—		8	48	½	03			195.94						35		
9	5	13.75	8	46	—		8	48	½	02			200.6[illegible]	—					34		
10	5	13.75	8	47	—		8	48	½	.03			205.83						[illegible]		
11	5½	[illegible].13	8	47	8	50	8	48	1	05	1	02	236.10						[illegible]		
12	6	16.50	8	4	—	—	16	.96	2	10	2	.03	206.00						[illegible]		
13	—	—	—	—	—	—	—	—		—			108.82								
			—	—	—	—	—	—		—			31.25								
		571.24		25.51		2.50		18.24		1.00		0.17	55[illegible].85								

Other expenses charged to Sinking . 1157.35

$6714.20

TIME, COST, AND MATERIALS USED IN FOUNDATIONS.

PIER C.

Date 1886 Sept.	Principal Foreman Days	Amount	Night Foreman Days	Amount	Sub-Foreman Days	Amount	Lock-Tenders Days	Amount	Pressure-Men Days	Amount	Coffee-House Men Days	Amount	Coffee Lbs	Amount	Sugar Lbs	Amount	Candles Number	Amount	Incandescent Lamps Number	Amount	Red Lead Lbs	Amount	Wick Balls	Amount	Coal for Heating Tons	Amount	Linseed Oil Gals	Amount	Sacking out Material Days	Amount	Master Mechanic Days	Amount	Electrician Days	Amount	Engineers at Compressors Days	Amount	Engineers at Pumps Days	Amount	Firemen at Compressors Days	Amount	Firemen at Pump Days	Amount	Coal for Compressor Boilers Tons	Amount	Coal for Pump Boilers Tons	Amount	Black Oil Pints	Amount	Lard Oil Pints	Amount	Tallow Lbs	Amount	Waste Lbs	Amount	Coal Oil Pints	Amount
18	1	$10.50	1	$3.85	6.3	$18.30	3.2	$7.20	30.4	$68.40	—	—	—	—	—	—	44	$0.99	—	—	25	$1.81	4	$0.10	2	$0.40	½	$0.06	—	—	2	$8.00	1	$2.50	4.1	$11.27	1.8	$4.95	3.5	$7.00	2.5	$5.00	2.5	$6.62	4.2	$11.13	—	—	8	$0.50	—	—	—	—	1	$0.01
19	1	5.00	1	3.50	3	9.00	2	4.50	23.0	51.75	1	$1.75	2	$0.48	3	$0.20	10	.22	—	—	—	—	—	—	2	.40	—	—	—	—	1	4.00	1	2.50	[illegible]	[illegible]	2.4	6.60	2.4	4.80	2.4	4.80	1.5	3.98	4.2	11.13	8	$0.47	2	.12	9	$0.54	½	$0.04	1	.02
20	1	5.00	1	3.50	3	9.00	2	4.50	26.0	58.50	2	3.50	2	.48	3	.20	3	.07	—	—	—	—	—	—	2	.40	—	—	—	—	1	4.00	1	2.50	2.1	5.77	2.4	6.60	2.4	5.17	2.4	4.80	1.5	3.97	4.2	11.13	5½	.30	—	—	6½	.39	1	.06	1	.01
21	1	5.00	1	3.50	3	9.00	2	4.50	29.0	65.25	2	3.50	2	.48	1½	.10	6	.13	—	—	—	—	2	.05	2	.40	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.0	5.30	4.8	12.72	5	.29	—	—	5	.30	1	.05	1	.02
22	1	5.00	1	3.50	3	9.00	2	4.50	27.0	60.75	2	3.50	2	.48	2	.13	2	.05	—	—	—	—	—	—	2	.39	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	1.5	3.98	4.8	12.72	4	.23	—	—	3	.18	½	.03	—	—
23	1	5.00	1	3.50	3	9.00	2	4.50	27.0	60.75	2	3.50	4	.96	6	.40	10	.23	—	—	35	1.81	—	—	2	.40	¼	.07	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	1.5	3.97	4.8	12.72	3½	.19	—	—	5	.30	1	.06	1	.01
Totals		220.50		155.10		5[illegible].50		220.[illegible]		3[illegible].32		1[illegible]		30.[illegible]		1[illegible].44		[illegible]		32.80		8.12		0.36		[illegible]		0.63		88.88		176.00		107.50		28[illegible].46		233.55		208.97		206.60		[illegible]80.89		341.93		137[illegible]		[illegible].53		13.65		2.11		0.53

Date	Totals for each Day	Feet sunk in 24 Hours	Material	Worthington Pumps, Hours run			Air Compressors		Remarks
Sept. 18	$168.59	—	Fine sand.	22	38	35	18	6.20	Air pressure put on at 5 P. M. on the 17th. Pump started at 10 A. M. Screws removed at 2 P. M.
19	123.32	3.46	" "	23	38	35	[illegible]	9.00	
20	129.85	4.29	" "	20	39	34	22	10.00	
21	139.88	2.22	" "	11	43	32	16	10.50	
22	133.75	0.03	" "	0	0	—	21	11.50	
23	136.6[illegible]	3.33	" "	9	—	35	[illegible]	[illegible]	
24	[illegible]	[illegible]	" "	[illegible]	—	30	[illegible]	[illegible]	
25	128.[illegible]	4.0[illegible]	" "	[illegible]	25	31	1	[illegible]	
26	1[illegible]9.10	[illegible]	" "	[illegible]	—	32	[illegible]	[illegible]	
27	130.7	3.61	" "	19	—	37	[illegible]	[illegible]	
28	1[illegible]	3.31	" "	0	3	37	[illegible]	[illegible]50	
29	129.[illegible]	4.0[illegible]	" "	15½	[illegible]	32	[illegible]	[illegible]50	
30	130.50	0.45	" "	0	0	—	1	[illegible]	Pump stopped waiting for masonry. Strong wind
Oct. 1	137.50	[illegible].35	Fine sand	10	40	33	25	[illegible]	
2	139.75	4.21	" "	[illegible]	37	33	1	[illegible]	
3	137.43	2.64	Gravel and sand	[illegible]	[illegible]	37	[illegible]	[illegible].50	
4	172.39	2.86	" "	24	42	26	50	29.00	
5	167.55	2.90	Coarse gravel and sand.	24	35	34	38	30.00	
6	161.4	[illegible].80	" "	22½	[illegible]	3	[illegible]	31.00	
7	16[illegible].45	0.10	" "	24	44	39	36	31.00	
8	178.37	0.10	Gravel, sand, and mud	16⅝	44	37	40	31.50	
9	172.14	2.00	" "	16[illegible]	[illegible]	40	35	3[illegible].00	
10	183.66	0.26	" "	14	43	10	[illegible]	[illegible]	
11	1[illegible]4.9[illegible]	[illegible]	" "	[illegible]	45	40	[illegible]	33.00	
12	[illegible]35.5[illegible]	0.10	" "	[illegible]	5	[illegible]	30	[illegible].00	
13	[illegible]	[illegible].54	" "	[illegible]	10	0	[illegible]	[illegible]	
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
15	176.17	0.91	" "	13½	41	48	26	34.00	
16	145.84	1.84	" "	8	41	40	20	34.50	
17	231.58	0.01	" "	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
18	1[illegible].65	2.36	" "	[illegible]	[illegible]	52	[illegible]	[illegible]	
19	169.0[illegible]	0.01	" "	10¼	39	49	48	3[illegible].00	
20	171.99	1.57	" "	16	45	46	52	37.00	Caisson landed on bed-rock at 5.20 P. M
21	178.72	—	— —	[illegible]	43	53	40	[illegible]	
22	17[illegible].5[illegible]	—	—	¼	3	[illegible]	[illegible]	[illegible]	
23	168.51	—	— —	11	43	[illegible]	40	37.00	
24	168.85	—	— —	11¼	40	47	40	37.00	
25	163.36	—	— —	—	—	—	52	37.00	Both compressors running during 18 hours with 36 revolutions per minute
26	160.80		— —	—	—	—	46	37.00	
27	158.5[illegible]	—	— —				[illegible]	[illegible]	
28	15[illegible].56			—		—	[illegible]	3[illegible].00	
29	160.47	—			—		18	35.0[illegible]	
30	157.76		— —	—	—	—	20	35.00	
31	148.79	—	— —	—	—	—	16	35.00	Pressure taken off at 9 A. M. on the 31st
Total	6893.2[illegible]								

Other expenses charged to Sinking . . $819.93

$7713.15

TIME, COST, AND MATERIALS USED IN FOUNDATIONS.

PIER D.

Date	Principal Foreman Days	Principal Foreman Amount	Night Foreman Days	Night Foreman Amount	[illegible] Days	[illegible] Amount	[illegible] Days	[illegible] Amount	Pressure-Men Days	Pressure-Men Amount	Coffee-house Men Days	Coffee-house Men Amount	Coffee Lbs.	Coffee Amount	Sugar Lbs.	Sugar Amount	Candles Number	Candles Amount	Incandescent Lamps Number	Incandescent Lamps Amount	Red Lead Lbs.	Red Lead Amount	Wick Yards	Wick Amount	Coal for Heating Tons	Coal for Heating Amount	Linseed Oil Pints	Linseed Oil Amount	Sacking out Material Days	Sacking out Material Amount	Master Mechanic Days	Master Mechanic Amount	Electrician Days	Electrician Amount	Engineers at Compressors Days	Engineers at Compressors Amount	Engineers at Pump Days	Engineers at Pump Amount	Firemen at Compressors Days	Firemen at Compressors Amount	Firemen at Pump Days	Firemen at Pump Amount	Coal for Compressor Boilers Tons	Coal for Compressor Boilers Amount	Coal for Pump Boilers Tons	Coal for Pump Boilers Amount	Black Oil Pints	Black Oil Amount	Lard Oil Pints	Lard Oil Amount	Tallow Lbs.	Tallow Amount	Waste Lbs.	Waste Amount	Cyl. Oil Pints	Cyl. Oil Amount	Totals for each Day	[illegible]	Material	Working Pump Hours	Working Pump Rev. per Min.	Working Pump [illegible]	Air Compressors Rev. per Min.	Air Compressors Air Gauge	Remarks.
1886. Nov. 3	1	$5.00	1	$3.50	3	$9.00	2	$4.50	27.0	[illegible]	2	$3.50	3½	$0.70	6	$0.40	11	$0.25	1	$0.85	[illegible]	[illegible]	3	$0.07	2.5	$0.33	1	$0.0[illegible]		—	1	$4.00	1	$2.50	2.4	$6.60	2.4	$6.60	2.4	$4.80	2.4	$4.80	1.5	$3.97	2.8	$7.42	5½	$0.31	2	$0.12	5	$0.30	1½	$0.07	—	—	121.89	3.54	Fine river sand	16½	43	45	12	7.50	Air pressure put on at 11 A.M. Pump started at 2.30 P.M.
4	1	5.00	1	3.50	3	9.00	2	4.50	27.0	[illegible]	2	3.50	3½	.84	5	.34	—		—					—	2.5	.33	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	1.5	3.98	2.8	7.42	6½	.38	2½	.14	5	.30	1	.06	—	—	129.34	1.97	" "	16½	32	47	16	9.00	
5	1	5.00	1	3.50	3	9.00	2	4.50	26.0	58.50	2	3.50	2	.48	6	.41			1	.85	—	—	—		3.8	.50			—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	1.5	3.97	2.8	7.42	4	.33	2	.13	3	.18	½	.03	2	$0.03	127.53	1.38	" "	—	—	—	14	9.00	Pump stopped; waiting for masonry
6	1	5.00	1	3.50	3	9.00	2	4.50	27.0	60.75	2	3.50	3	.72	5	.34		—	—	—	—				3.6	.48	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	1.5	3.98	2.8	7.42	6	.35	2½	.14	6½	.39	1	.06	—	—	129.43	5.18	" "	2½	37	40	16	3.00	
7	1	5.00	1	3.50	3	9.00	2	4.50	25.0	[illegible]	2	3.50	2¼	.51	5	.34	—	—	—		25	1.81	2	.05	3.8	.50	1	.03	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	1.5	3.97	2.9	7.69	5	.29	2¼	.14	4	.24	1	.06	—	—	126.70	3.98	" "	9¼	39	4[illegible]	22	15.00	
8	1	5.00	1	3.50	3	9.00	2	4.50	[illegible]	[illegible]	2	3.50	2	.45	5	.33			—		—	—			3.8	.51			—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.0	5.30	2.9	7.69	6	.35	4½	.26	6½	.39	1	.06	—	—	130.92	2.98	" "	14½	37	15	14	6.50	
9	1	5.00	1	3.50	3	9.00	2	4.50	25.0	56.25	2	3.50	2¼	.54	5	.34					—				3.8	.50		—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.0	5.30	2.8	7.42	5½	.32	4½	.27	4½	.25	1	.06	—	—	126.05	4.97	" "	17½	43	[illegible]	20	8.50	
10	1	5.00	1	3.50	3	9.00	2	4.50	[illegible]	58.50	2	3.50	2¼	.54	5	.34	—	—	—				—	—	5	.60	—		—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.0	5.30	2.9	7.68	5½	.32	2½	.14	7	.42	1	.05	—	—	128.70	4.21	" "	13½	42	50	[illegible]	10.00	
11	1	5.00	1	3.50	3	9.00	2	4.50	25.0	56.25	2	3.50	3	.71	5	.34			—	—	25	1.81	[illegible]	.05	5.0	.60	1	.03	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.0	5.30	2.9	7.69	5	.29	2½	.14	5	.30	1	.05	—	—	128.43	2.48	" "	9	40	4[illegible]	30	[illegible]	
12	1	5.00	1	3.50	3	9.00	2	4.50	27.0	60.75	2	3.50	2¼	.54	5	.33									3.9	.51	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.5	6.62	2.9	7.68	4½	.28	4½	.26	6	.36	1	.06	—	—	132.19	2.64	" "	[illegible]	42	19	30	[illegible]	
13	1	5.00	1	3.50	3	[illegible]	2	5.00	[illegible]	[illegible]	2	3.50	[illegible]	[illegible]	[illegible]	[illegible]					—	—	—	—	3.5	.40	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.5	6.63	2.9	7.69	8	.47	4½	.27	7	.42	1	.06	2	.03	135.51	5.94	" "	16½	45	4[illegible]	3[illegible]	[illegible]	
14	1	5.00	1	3.50	3	9.75	2	5.00	27.0	[illegible]	2	3.50	5	1.20	6	.40	—		—	—	—	—			3.8	.50	—			—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.0	5.30	2.9	7.68	5½	.32	2½	.14	7	.42	1	.06	—	—	139.57	2.17	" "	15½	36	13	30	[illegible]	
15	1	5.00	1	3.50	4	13.00	2	5.00	32.0	80.00	2	3.50	3½	.80	6	.41									4.0	.53	—				1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.5	6.62	3.0	7.95	7	.41	4½	.26	7	.42	1	.06	2	.03	156.79	1.43	Gravel, sand, and some clay.	[illegible]	41	15	30	[illegible]	
16	1	5.00	1	3.50	4	13.00	2	5.00	36.0	90.00	2	3.50	3½	.84	7	.47	—	—			—		—	—	6.0	.79	—		—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	2.5	6.63	1.6	4.06	6	.35	2½	.14	7	.42	½	.06	—	—	163.06	[illegible]	" "	3¼	[illegible]	[illegible]	34	[illegible]	
17	1	5.00	1	3.50	4	13.00	2	5.00	36.0	90.00	2	3.50	4½	1.08	8	.54	—	—			—				7.0	.93	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.0	7.95	1.6	4.06	8½	.49	2	.12	5	.30	½	.05	—	—	164.82	2.31	" "	2¼	42	42	36	20.00	Air pipe frozen; ran up pressure in engine room to 5[illegible] lbs. River blockaded with ice above pile bridge.
18	1	5.00	1	3.50	4	13.00	2	5.00	35.0	87.50	2	3.50	3½	.84	7	.47	—	—	2	1.70	—		—	—	4.5	.60	—	—	6.9	12.10	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.5	11.92	1.6	4.06	8½	.49	2	.13	7½	.45	½	.04	2	.03	179.63	0.05	" "	19½	42	42	48	29.00	Air pipe frozen 9.45 A.M. Air hose frozen 7 P.M. Both compressors running since 11 P.M. on the 17th at 26 revolutions per minute. Sacking out gravel.
19	1	5.00	1	3.50	4	13.00	2	5.00	36.0	90.00	2	3.50	3⅜	.90	7	.47	—	—	—	—	—	—	—	—	5.0	.66	—	—	1.3	2.25	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.5	9.27	1.7	4.50	8½	.47	2¼	.17	7	.42	½	.05	—	—	168.46	0.01	" "	12	42	43	46	29.00	Both compressors running until 1.30 A.M. on the 20th at 36 revolutions per minute each.
20	1	5.00	1	3.50	4	13.00	2	5.00	36.0	90.00	2	3.50	3½	.84	6	.40	—	—	—	—	—	—	—	—	4.5	.59	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.0	7.95	1.7	4.51	6	.35	2	.12	4	.24	½	.03	—	—	164.33	—	" "	—	—	—	34	29.00	No pumping done. Waiting for masonry. Jetting under derrick-boat to get it off the sand-bar.
21	1	5.00	1	3.50	4	13.00	2	5.00	36.0	90.00	2	3.50	3⅜	.90	5	.34	—	—	—	—	—	—	—	—	4.0	.53	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	1.7	4.50	9½	.54	2½	.17	9	.54	1	.06	2	.03	167.51	1.66	" "	8	43	42	(*)	30.00	(*) One compressor 18 hrs. at 36 revolutions per minute. Two compressors 6 hrs. at 30 revolutions per minute each.
22	1	5.00	1	3.50	4	13.00	2	5.00	36.0	90.00	2	3.50	2½	.60	6	.41	—	—	—	—	—	—	—	—	4.0	.53	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.5	9.28	1.7	4.51	9	.53	4½	.27	7	.42	½	.04	—	—	165.89	0.48	" "	12	44	42	42	30.00	One compressor 6 hrs. at 42 revolutions per minute. Two compressors 18 hrs. at 30 revolutions per minute each.
23	1	5.00	1	3.50	4	13.00	2	5.00	[illegible]	90.00	2	3.50	1¼	1.0[illegible]	6	.40	—	—	—	—	25	1.81	2	.05	1.0	.53	8	.50	5.7	9.90	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	5.0	13.25	2.5	6.62	10	.88	2½	.17	11½	.69	1½	.09	—	—	185.21	0.97	" "	20	45	47	46	30.50	One compressor 6 hrs. at 46 revolutions per minute. Two compressors 18 hrs. at 50 revolutions per minute each.
24	1	5.00	1	3.50	4	13.00	2	5.00	35.0	[illegible]	2	3.50	3	[illegible]	8	.54	—	—	—	—	—	—	—	—	4.5	.60	—	—	3.2	5.55	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.5	9.27	2.5	6.63	9½	.55	2½	[illegible]	7	.42	1	[illegible]	2	.04	171.35	0.46	" "	12½	45	42	42	30.50	Two compressors 6 hrs. at 38 revolutions per minute each. One compressor 18 hrs. at 42 revolutions per minute.
25	1	5.00	1	3.50	4	13.00	2	5.00	[illegible]	90.00	2	3.50	3	[illegible]	7	[illegible]	—	—	—	—	—	—	—	—	1.2	.56	—	—	6.9	12.00	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	2.6	6.89	8	.47	4½	.29	7	.42	1	.06	—	—	181.78	0.98	" "	20½	44	48	50	30.50	One compressor running
26	1	5.00	1	3.50	4	13.00	2	5.00	34.0	85.00	2	3.50	3½	[illegible]	7	[illegible]	—	—	—	—	—	—	—	—	4.0	.53	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.5	9.28	2.6	6.89	7½	.42	2½	.18	7	.42	1	.05	—	—	163.15	0.36	" "	13	42	46	38	30.50	
27	1	5.00	1	3.50	4	13.00	2	5.00	34.0	[illegible]	2	3.50	3	.72	7	[illegible]	—	—	—	—	—	—	—	—	1.0	.53	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	2.8	7.42	9½	.55	2½	.17	8	.48	1½	.09	—	—	170.34	0.89	" "	16½	40	49	40	31.50	One compressor 8 hrs. at 40 revolutions per minute. Two compressors 16 hrs. at [illegible] revolutions per minute each.
28	1	5.00	1	3.50	3	9.75	2	5.00	35.5	[illegible]	2	3.50	[illegible]	.60	6	.41	—	—	1	.85	—	—	—	—	4.0	.53	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	5.0	13.25	2.9	7.69	10	.58	3½	.21	9	.54	1	.06	—	—	168.67	1.16	" "	19½	46	45	38	31.50	Two compressors running
29	1	5.00	1	3.50	3	9.75	2	5.00	35.0	[illegible]	2	3.50	1	.21	4	.27	—	—	1	.85	—	—	—	—	3.0	.40	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	2.9	7.68	8	.47	¼	.02	7½	.45	½	.05	—	—	164.44	0.88	" "	19	42	41	31	31.50	One compressor running
30	1	5.00	1	3.50	[illegible]	[illegible]	2	5.00	35.0	87.50	2	3.50	1	.24	—														—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.5	11.93	2.9	7.69	10	.59	2	.13	6½	.39	1	.06		—	169.08	0.79	" "	12⅝	39	34	30	32.00	Two compressors 12 hrs., one compressor 7½ hrs.
Dec.	1	5.00	1	3.50	[illegible]	13.00	2	5.00	33.0	82.50	2	3.50	3	[illegible]	6	.40	—	—	+	3.40	—	—	—	—	5.0	.66	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.2	8.48	3.0	7.95	5¼	.30	2	.12	6	.36	1	.06	—	—	164.25	—	— —	15¼	43	32	30	32.50	One compressor 8 hrs., two compressors 8⅝ hrs. Compressors stopped from 2.30 A.M. till 2.30 P.M. Dec. 1st, on account of air pipe frozen.
2	1	5.00	1	3.50	4	13.00	2	5.00	35.0	87.50	2	3.50	3	.72	7	.47	—	—	—	—	—	—	—	—	5.0	.67	—	—	2.8	4.88	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	3.0	7.95	8	.47	—	—	8½	.51	¼	.04	—	—	173.11	—	— —	19	39	32	54	32.50	
3	1	5.00	1	3.50	4	13.00	2	5.00	34.0	85.00	2	3.50	3¼	.84	6	.41	—	—	—	—	25	1.82	2	.05	4.8	.64	8	.50	4.0	7.00	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	3.0	7.95	5¼	.31	4	.25	6	.36	1	.06	—	—	175.09	—	— —	1¼	30	32	33	32.50	Pump stopped 8.45 A.M.
4	1	5.00	1	3.50	4	13.00	2	5.00	34.0	85.00	2	3.50	3⅜	.84	9	.61	—	—	—	—	—	—	—	—	5.5	.73	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	—	—	8	.48	2	.13	4	.24	½	.03		—	157.96	—	— —	—		—	32	32.50	
5	1	5.00	1	3.50	4	13.00	2	5.00	35.0	87.50	2	3.50	3¾	.90	9	.61	—	—	—	—	—	—	—	—	5.5	.73	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.5	11.92	—	—	12	.70	4	.25	5	.30	½	.03	—	—	162.24	—	— —	[illegible]	—	[illegible]	[illegible]	[illegible]	
6	1	5.00	1	3.50	4	13.00	2	5.00	34.0	85.00	2	3.50	3	.72	8	.54	—	—	—	—	—	—	—	—	4.5	.60	—	—	—	—	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.0	10.60	—	—	8	.47	4	.25	2	.12	½	.03	—	—	157.63	—	— —	—		—	30	3[illegible].00	
7	1	5.00	2	7.00	4	13.00	3	7.50	64.0	160.00	3	5.25	1	.24	3	.20	—	—	—	—	—	—	—	—	2.0	.27	—	—	—	—	2	8.00	2	5.00	4.8	13.20	4.8	13.20	4.8	9.60	4.8	9.60	2.5	6.62	—	—	6	.35	—	—	—	[illegible]	1	.06	—	—	264.09	—	— —	—	—	—	14	32.00	Pressure taken off 12 o'clock night, Dec. 7–8
		1[illegible]5.00		126.00		402.00		17[illegible].50		2794.50		1[illegible]4.25		[illegible]4.80		13.97		0.25		8.50		9.[illegible]9		0.27		19.[illegible]8		1.12		53.68		1[illegible]4.00		90.00		[illegible]7.60		237.60		1[illegible]2.80		1[illegible]7.80		288.04		210.40		15.13		5.87		12.88		1.92		0.19	5515.14								

Other expenses charged to Sinking [illegible]51.58

= $5,766.72

TIME, COST, AND MATERIALS USED IN FOUNDATIONS.

PIER E.

Date	Principal Foreman Days	Principal Foreman Amount	Night Foreman Days	Night Foreman Amount	[illegible] Foremen Days	[illegible] Foremen Amount	Lock Tenders Days	Lock Tenders Amount	Pressure Men Days	Pressure Men Amount	[illegible] Men Days	[illegible] Men Amount	Coffee Lbs.	Coffee Amount	Sugar Lbs.	Sugar Amount	Candles Number	Candles Amount	Carbons for Lamps Number	Carbons for Lamps Amount	Red Lead Lbs.	Red Lead Amount	Wick Lbs.	Wick Amount
1887 Jan.																								
9	1	$5.00	1	$3.50		—	—					—	2	$0.[illegible]5	3	$0.30		$0.04	1	$0.3[illegible]	[illegible]	[illegible]	¼	$0.1[illegible]
10	1	5[illegible]	1	3.50	2	$6.00	1	$2.25	9.00	$20.25	1	$[illegible]	2	45	3	2[illegible]		.04			—			
11	1	5.00	1	3.50	3	[illegible].00	2	4.50	27.00	60.75	1	[illegible]	2	48	3	20		.04						—
12	1	5.00	1	3.50	3	[illegible].00	2	4.50	30.00	[illegible]50	2	3.50	2	45	3	20		.04		—	—	—		
13	1	5[illegible]	1	3.50	3	[illegible]00	2	4.50	27.00	60.75	2	3.50	2	4[illegible]	3	20	[illegible]	.0[illegible]						
14	1	5.00	1	3.50	2	9.00	2	4.50	27.00	60.75	2	3.50	2	45	3	20		.04		—	—			
15	1	5.00	1	3.50	3	[illegible].00	2	4.50	27.00	60.75	2	3.50	3	[illegible]	3	20		.01				—		
16	1	5.00	1	3.50	3	[illegible].00	2	4.50	27.00	60.75	2	3.50	3	[illegible]	[illegible]	21		.04						—
17		5.00	1	3.50	3	[illegible].00	2	4.50	[illegible].00	[illegible]	2	3.50	1½	42	3½	24				—		—		
18	1	5.00	1	3.50	3	9.00	2	[illegible]50	23.00	[illegible]	2	3.50	1¾	54	[illegible]	24		—						
19	1	5.00	1	3.50	3	[illegible]		[illegible]	24.00	[illegible]00	2	3.50	¾	4[illegible]	3½	23	—				—			
20	1	5.00	1	3.50	2	[illegible]	2	4.50	[illegible]3.00	5[illegible]	2	3.50	2	48	3	20				—	—			
21	1	5.00	1	3.50	3	9.00	2	4.50	[illegible]8.00	63.00	2	3.50	2	48	3½	21		—						—
22	1	5.00		3.50	3	9.00	2	4.50	27.00	60.75	2	3.50	2	45	4	2[illegible]								
23	1	5.00	1	3.50	3	[illegible]00	2	[illegible]50	27.00	60[illegible]	2	3.50	2½	60	4	2[illegible]		—					—	
24	1	5.00	1	3.50	3	9.00	2	4.50	26.00	[illegible]50	2	3.50	2½	60	4	27		—			—			
25	1	5.00	1	3.50	4	13.00	2	[illegible].00	[illegible]	[illegible]	2	3.50	2½	60	5	31	—				—		—	
26	1	5.00	1	3.50	4	13.00	2	5.00	[illegible].50	9[illegible]	2	3.50	3	[illegible]	5	34	—		—		—			
27	1	5.00	1	3.50	4	13.00	2	5.00	[illegible]5.00	[illegible]	2	3.50	3	[illegible]	4½	30	—		—					
28	1	5.00	1	3.50	4	13.00	2	5.00	[illegible]	[illegible]	2	3.50	3	[illegible]	5			—			—			
29	1	5.00	1	3.50	4	13.00	1	2.50	3[illegible]	[illegible]	2	3.50	3	[illegible]	5	33		—			—	—		
30	1	5.00	1	3.50	3	10.2[illegible]	2	5.00	36.00	90.00	2	3.50	3	[illegible]	5	31	—	—	1	85			—	
31	1	5.00		3.50	4	13.00	2	5.00	3[illegible] 50	92.50	2	3.50	3	[illegible]2	5	34			1	85	—	—		
Feb.																								
1	1	5.00	1	3.50	4	13.00	2	5.00	4[illegible]	101.[illegible]	2	3.50	3	73	5¼	39								
2	1	5.00	1	3.50	4	13.00	2	5.00	3[illegible].00	90.00	2	3.50	3	72	6¼	4[illegible]					—	—		
3	1	5.00	1	3.50	4	13.00	2	5.00	3[illegible].00	[illegible]5.00	2	3.50	2¾	66	1¾	30	—	—	1	85				—
4	1	5.00	1	3.50	4	13.00	2	5.00	3[illegible].00	[illegible]7.5[illegible]	2	3.50	3	72	4½	31					—			
5	1	5.00	1	3.50	4	13.00	2	5.00	40.00	100.00	2	3.50	3	72	4½	30	—	—		—				—
6	1	5.00	1	3.50	4	1[illegible]00	2	5.00	[illegible].00	[illegible]	2	3.50	3	[illegible]	4½	30	—							
7	1	5.00	1	3.50	4	[illegible]3.00	2	5.00	35.50	[illegible]75	2	3.50	3	[illegible]2	5	34		—			—			—
8	1	5.00	1	3.50	4	13.00	2	5.00	36.50	91.[illegible]	2	3.50	2¾	[illegible]	5¼	[illegible]	—		1	85				
9	1	5.00	1	3.5		[illegible]	2	5.00	37.00	92.50	2	3.50	[illegible]	[illegible]0	5	33					—	—		—
10	1	5.00	1	3.5	4	13.[illegible]	2	5.00	34.50	[illegible]	2	3.50	[illegible]	[illegible]	4	3[illegible]			2	1.70	—	—		—
11	1	5.00	1	3.50	4	13.00	2	5.00	37.00	92.50	2	3.50	2½	[illegible]0	4	27								
12	1	5.0[illegible]	1	3.50	4	1[illegible]	2	5.00	3[illegible].00	92.50	2	3.50	[illegible]	[illegible]	4	30				—				—
13	1	5.0[illegible]		3.50	4	[illegible]3.00	2	5.00	34.00	85.00	2	3.50	2¼	[illegible]	4¾	30					—			
14	1	5.00	1	3.50	4	13.00	2	5.00	3[illegible].50	[illegible]75	2	3.50	2¼	[illegible]	[illegible]	30		—	1	85				
15	1	5.[illegible]0	1	3.50	4	1[illegible].00	2	5.[illegible]0	[illegible] 50	[illegible]	2	3.50	[illegible]	[illegible]4	[illegible]	[illegible]	—	—			—	—		
16	1	5.0[illegible]	1	3.50	4	1[illegible].00	2	5.[illegible]0	3[illegible].00	95.00	2	3.50	2	[illegible]	[illegible]	27	—				—	—		—
17	1	5.00	1	3.50	4	13.00		2.[illegible]0	3[illegible]	[illegible]	2	3.50	[illegible]	4[illegible]	4	[illegible]					—	—		—
18	1	5.00	1	3.50	4	13.00	1	2.50	3[illegible].00	95.00	2	3.[illegible]0	2	51	1	[illegible]7				[illegible]5	[illegible]	1.8[illegible]	[illegible]	15
19	1	5.00	1	3.50	4	13.00	1	2.50	[illegible]	[illegible]	2	3.[illegible]	2	51	1	[illegible]								
20	1	5.00	1	3.50	4	13.00	1	2.50	35.00	[illegible]	2	3.[illegible]	2	[illegible]	—	—								
21	1	5.00	1	3.[illegible]	4	[illegible]3.00	1	2.50	34.00	[illegible]5.00	2	3.50	[illegible]	[illegible]										—
22	1	5.00	2	[illegible].00	3	9.75	2	5.00	50.50	1[illegible]25	1	7.00	[illegible]	40	—				—					
																	[illegible]0	90			[illegible]5	1.8[illegible]	[illegible]	19
		225.00		161.00		305.[illegible]		195.25		3571.1[illegible]		154.00		[illegible]6.[illegible]6		11.[illegible]		1.32		[illegible]		5.13		0.44

Date	Coal for Heating [illegible]	Coal for Heating Amount	Linseed Oil Pints	Linseed Oil Amount	Sacking, etc., Materials [illegible]	Sacking, etc., Materials Amount	Master Mechanic Days	Master Mechanic Amount	Electrician Days	Electrician Amount	Engineers at Compressors Days	Engineers at Compressors Amount	Engineers at Pumps Days	Engineers at Pumps Amount	Firemen at Compressors Days	Firemen at Compressors Amount	Firemen at Pumps Days	Firemen at Pumps Amount	Coal for Compressor Boilers Tons	Coal for Compressor Boilers Amount	Coal for Pump Boilers Tons	Coal for Pump Boilers Amount	Black Oil Pints	Black Oil Amount	Lard Oil Pints	Lard Oil Amount
Jan. 9	3[illegible]	[illegible]	[illegible]	$0.0[illegible]				$4.00		$2.50	[illegible]	$6.60	1.2	$3.3[illegible]	[illegible]	$4.[illegible]	2.4	$4.80	.5	$3.[illegible]			2	$0.12	1	$0.0[illegible]
10	3.0	4[illegible]				—	1	4.[illegible]0		[illegible].50	2.4	6.[illegible]	2	[illegible]	2.4	4.80	1	[illegible]0	1.5	3.[illegible]			1	[illegible]3	—	
11	3.0	10	—	—			1	4.00		2.50	[illegible]		[illegible]	6.00	[illegible]	[illegible].00	[illegible]	4.80	2.5	6.62			1	2[illegible]	1	.0[illegible]
12	[illegible]	[illegible]				—	1	4.00	1	[illegible].50	2.4	6.00	2.4	6.0[illegible]	[illegible]	[illegible]0	2.4	4.50	[illegible]	[illegible]3			1	2[illegible]	—	
13	3.0	40			—		1	4.00	1	2.50	2	6.60	2.4	6.60	2.4	[illegible]	[illegible]	4.80	2.5	6.62	3.0	$7.[illegible]5	1	[illegible]		
14	[illegible]	[illegible]0				—	1	4.00	1	[illegible]0	[illegible]	6.60	[illegible]	6.60	2.4	4.80	2.4	4.80	2.5	6.6[illegible]	3.	[illegible].21	6	35	2	15
15	3.0	4[illegible]					1	4.00		[illegible]50	2.4	6.60	2.4	6.60	2.4	4.[illegible]0	2.4	4.80	2.5	6.33	3.1	[illegible].2[illegible]	[illegible]	4[illegible]		02
16	3.0	[illegible]	—	—			1	4.00		2.50	2.4	[illegible].60	2.4	6.60	2.4	4.80	2.4	4.80	3.0	7.95	3.1	[illegible].21	6¾	3	[illegible]	16
17	3[illegible]					—	1	4.00	1	[illegible]50	2.4	[illegible]	2.4	6.60	2.1	[illegible]0	2.4	4.80	3.0	7.9[illegible]	3.1	[illegible]	5	2	[illegible]	03
18	3.5		—				1	4.00	1	2.50	2.4	[illegible]	2.4	6.60	2.4	4.80	2.4	4.80	3.0	7.9[illegible]	3.	8.[illegible]		44	2½	[illegible]
19	[illegible]0	[illegible]	—	—	—	—	1	4.[illegible]	1	2.50	2.4	6.00	2.4	6.60	2.4	4.80	2.4	4.80	3.0	7.95	3.3	6.10	7½	.44	2½	.16
20	[illegible]	44						4.00	1	[illegible]50	[illegible]	6.60	[illegible]	6.60	[illegible]	4.80	2.4	4.80	3.0	7.0[illegible]	[illegible]3	6.09	7	[illegible]	[illegible]	03
21	3[illegible]	12	—		—		1	4.00	1	[illegible]50	[illegible]	6.[illegible]0	2.4	[illegible]	[illegible]	4.80	2.4	4.80	3.0	7.96	2.3	[illegible]10	6	35	4¼	.2[illegible]
22	3.4	15		—		—	1	4.0[illegible]	1	2.50	[illegible]	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.7	9.80	3.3	6.09	8	.47	4½	.28
23	2[illegible]	37					1	4.00		2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.7	9.81	2.4	6.36	8	.47	2¼	.14
24	3[illegible]	43			—	—	1	[illegible].00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.7	9.80	2.4	6.36	6	.35	2¼	.14
25	3[illegible]	45					1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.7	9.81	2.4	6.36	8	.47	2¼	.14
26	[illegible]4	45			5.00	$8.7[illegible]	1	4.00		2.50	2.4	6.6[illegible]	[illegible]	6.60	2.4	4.80	2.4	4.80	3.8	10.07	3.5	9.28	8	.47	2	.12
27	3[illegible]	45		—	5.00	8.7[illegible]	[illegible]	4.00	1	2.50	[illegible]	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.8	10.07	3.6	9.54	10	.58	¼	.01
28	3[illegible]	[illegible]	—		1[illegible].60	27.30	1	4.00	1	[illegible]50	2.4	6.60	[illegible]	6.60	2.4	4.80	2.4	4.80	3.8	10.07	3.6	9.54	7½	.42	2	.13
29	[illegible]7	4[illegible]	—	—	10.10	[illegible]75	1	4.00	1	[illegible]50	[illegible]	6.60	[illegible]	6.[illegible]	[illegible]	4.80	2.4	4.80	3.8	10.07	3.6	9.5[illegible]		.41	[illegible]	.1[illegible]
30	37	48			[illegible]	15.0[illegible]	1	4.00	1	[illegible]50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.7	9.80	3.5	9.27	8	.46	2¼	.14
31	37	40			[illegible]00	[illegible]75	1	4.00	1	2.50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	3.7	9.81	3.6	9.54	7½	.44	2¼	.14
Feb. 1	37	48	—	—		—	1	4.00		[illegible]50	[illegible]	6.60	[illegible]	[illegible]60	2.4	4.80	2.4	4.80	3.8	10.0	3.6	9.54	8	.4[illegible]	2¼	.14
2	37	48			10.25	[illegible]	1	4.[illegible]	1	2.50	2.4	6.[illegible]0	[illegible]	[illegible].00	[illegible]	4.80	[illegible]	[illegible]80	3.8	10.07	3.6	[illegible]	[illegible]	.35	2¼	.1[illegible]
3	3[illegible]	48			[illegible]	[illegible]	1	4.0[illegible]	1	2.50	[illegible]	6.60	[illegible]	[illegible]	[illegible]	4.80	2.4	4.80	4.5	11.92	1.9	5.03	5	[illegible]	[illegible]	.1[illegible]
4	37	[illegible]			[illegible]	[illegible]	1	4.00	1	[illegible]50	2.4	6.60	2.4	[illegible]	[illegible]	4.80	[illegible]	4.80	4.5	11.93	1.9	5.0[illegible]	6	35	[illegible]	.1[illegible]
5	37	48			[illegible]	[illegible]	1	4.00	1	2.50	[illegible]	6.60	[illegible]	[illegible]	[illegible]	4.80	[illegible]	4.80	4.5	11.92	1.9	5.03	7	.4	2¼	.1[illegible]
6	37	48	—		[illegible]	[illegible]	1	4.0[illegible]		[illegible]50	[illegible]	6.60	2	6.60	2	[illegible]00	2.4	4.80	4.5	11.[illegible]3	2.0	5.30		.41	2	.13
7	37	48			[illegible]	10.[illegible]	1	4.00		[illegible]50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.5	11.92	2.0	5.30	7	.41	3¼	.14
8	37	48			[illegible]	[illegible]0	1	4.00		[illegible]50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.5	11.93	2.0	5.30	6½	.38	2	.12
9	37	48			4.50	[illegible]		4.00	1	[illegible]50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.5	11.92	2.0	5.30	9	.53	2¼	.14
10	37	48		—	4.50	[illegible]	1	4.00		2.50	2.4	6.60	[illegible]	6.60	2.4	4.80	2.4	4.80	4.5	11.93	2.0	5.30	7	.4	[illegible]	.14
11	40	53	—		4.50	[illegible]	1	4.00		[illegible]50	2.4	6.60	3.4	9.35	2.4	4.80	2.4	4.80	4.5	11.92	2.0	5.30	5	30	2¼	.14
12	4[illegible]	53			[illegible]50	[illegible]	1	4.00	1	[illegible]50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.5	11.93	2.0	5.30	[illegible]	.41	[illegible]	.1[illegible]
13	[illegible]0	53			[illegible]50	[illegible]40	1	4.00		[illegible]50	2.4	6.60	2.4	6.60	2.4	4.80	2.4	4.80	4.6	12.19	[illegible]	5.30	9	53	[illegible]	[illegible]
14	[illegible]0	53					1	4.00	1	[illegible]50	2.4	[illegible]		[illegible]	[illegible]	4.[illegible]	[illegible]	4.8[illegible]	[illegible]	12.1[illegible]	3.0	5.30	[illegible]	3[illegible]	2¼	.14
15	40	53	—		—	—	1	4.00	1	2.50	[illegible]	6.6	[illegible]	6.[illegible]0	[illegible]	[illegible]	2.4	4.80		12.45	[illegible]6	[illegible]	[illegible]	.42	[illegible]	.1[illegible]
16	40	53	—		—		1	[illegible]00	1	[illegible]	[illegible]	[illegible]60	2.4	6.60	[illegible]	[illegible]80	[illegible]	[illegible]80	4.7	2[illegible]	[illegible]7	[illegible]5	6½	.37	4½	.2[illegible]
17	40	53	—			—	1	4.[illegible]0	1	[illegible]0	[illegible]	6.6[illegible]	[illegible]	[illegible]	[illegible]	4.80	[illegible]	4.80	4.7	1[illegible]	2.[illegible]	[illegible]16	[illegible]	.17		.13
18	40	53	[illegible]	2	—			4.00	1	[illegible]		[illegible]60	1.2	3.30	2.4	4.80	2.4	[illegible]80	4	12.16	[illegible]7	15	8	.17	2	.1[illegible]
19	40	53	—		6.50	11.[illegible]0	1	4.00	1	2.5	[illegible]	[illegible]0	1.2	3.30	[illegible]	4.[illegible]0	[illegible]	4.[illegible]0	[illegible]	43			[illegible]	4[illegible]	[illegible]	.1[illegible]
20	[illegible]0	53		—	5.[illegible]0	[illegible]0	1	4.00	1	2.50	[illegible]	6.60			2.4	4.80	2.4	4.80	[illegible]	1[illegible]3	—		[illegible]	[illegible]6	[illegible]	.2[illegible]
21	40	53		—	3.60	6.30	1	4.00	1	2.50	2.4	[illegible]0	—		2.4	4.80	[illegible]	4.80	6.3	6.60				35		
22	[illegible]0	53	—						1	2.50	[illegible]	6.[illegible]0	1.2	3.30	2.4	4.80	3.6	[illegible]0	[illegible]3	10.[illegible]	—		1	[illegible]	—	
			2½	16	—			—		—		—	—			—		—		—				—		—
		20.[illegible]		0.3[illegible]		221.25		[illegible]6.00		1[illegible]2.50		297.00		273.35		216.00		218.40		4[illegible]7.7[illegible]		259.[illegible]2		17.60		5.30

Date	Tallow Lbs.	Tallow Amount	Waste Lbs.	Waste Amount	[illegible] Oil Pints	[illegible] Oil Amount	Totals for each Day	Feet sunk in 24 Hours	Material	Working on Piers [illegible]	Working on Piers [illegible]	Water Gauge	Air Compressors Revs. p. M.	Air Compressors Gauge	Remarks
Jan. 9	2	$0.[illegible]2	1	$0.0[illegible]	2	$0.03	$[illegible]2.80	—	—			—	8	[illegible]00	Air pressure put on at 11 A.M.
10	3	15	[illegible]	.03	[illegible]	.0[illegible]	[illegible]			—	—		15	10.00	
11	3	15	[illegible]	.0[illegible]	[illegible]	[illegible]	1[illegible]2.05	0.2[illegible]	Fine river sand	—			24	10.00	Caisson landed on sand.
12	3	15	[illegible]	.03		—	[illegible]21.48	0.9[illegible]	"			—	3[illegible]	10.20	
13	3	15	[illegible]	.0[illegible]			[illegible]3.68	0.[illegible]			—	—	30	[illegible]0	
14	[illegible]	45	1½	.0[illegible]			1[illegible]	4.[illegible]0	"	2¼	[illegible]	30	3[illegible]	1.00	Sand pump started [illegible] A.M.
15	[illegible]	33	1	.0[illegible]	—	—	132.30	2.[illegible]		1[illegible]	34	44	2[illegible]	1[illegible].50	
16	5½	33	1	.01			[illegible].01	[illegible].01		10½	3[illegible]	4[illegible]	[illegible]	[illegible]00	
17	5	30	[illegible]	.01			[illegible]	2.[illegible]4		[illegible]	33	33	30	1.[illegible]	
18	[illegible]	3	1	.0[illegible]			135.02	2.33		1[illegible]	3[illegible]	3	[illegible]	[illegible]	
19	7	.42	1	.06		—	[illegible]24.9[illegible]	1.[illegible]	"	1[illegible]	3[illegible]	33	24	1[illegible]0	
20	4[illegible]	[illegible]	[illegible]	.0[illegible]			1[illegible]	0.0[illegible]	"	[illegible]	0	[illegible]3	[illegible]	1[illegible].50	Strong wind, waiting for masonry
21	9½	57	1	.0[illegible]		—	134.35	3.[illegible]5	"	2[illegible]	40	3[illegible]	2[illegible]	1[illegible].50	
22	7½	.45	1	.06	2	.04	133.9[illegible]	3.[illegible]0	Coarse sand, very coarse gravel, and occasion[illegible] [illegible] boulders	[illegible]	43	30	3[illegible]	[illegible].50	
23	7½	.45	1	.06		—	134.08	1.40	" "	2[illegible]	0	[illegible]	[illegible]2	[illegible].00	
24	7	.42	1	.06		—	131.79	1.54	"	24	41	12	30	[illegible]3.00	
25	8½	.51	1½	.10			175.58	0.96		24	[illegible]	[illegible]	1[illegible]	23.00	P[illegible] clay [illegible]
26	6	.36	½	.03		—	188.64	1.80		[illegible]	[illegible]3	4[illegible]	18	24.0[illegible]	
27	7½	.45	1	.06		—	1[illegible]	0.75	"	[illegible]	[illegible]3	[illegible]0	50	[illegible].00	
28	5½	.33	1	.06			201.1[illegible]	0.[illegible]	"	[illegible]	[illegible]	[illegible]	16	[illegible].00	
29	5	30	¾	.05		—	190.3[illegible]	1.[illegible]	"	13[illegible]	3[illegible]	[illegible]2	40	[illegible].00	
30	7½	.45	1	.06		—	190.17	0.11		[illegible]	[illegible]	[illegible]	4[illegible]	[illegible].00	C[illegible] struck [illegible] and abandoned
31	7	.42	1	.06		—	183.35	1.55	" "	[illegible]	[illegible]	3[illegible]	30	2[illegible]	
Feb. 1	[illegible]	51	1	.0[illegible]		—	183.35	1.17	" "	21	39	4	40	2[illegible].50	
2	[illegible]	2[illegible]	1	.01			18[illegible]	0.15	" "	[illegible]	43	1	35	[illegible].00	
3	3[illegible]	32	¾	.04		—	179.04	0.75	" "	9	48	47	35	[illegible].00	
4	7	4[illegible]	1	.01			180.35	0.[illegible]0	"	[illegible]	44	44	31	[illegible].00	
5	5[illegible]	33	¾	.05			190.14	1.10	"	2	1	30	42	25.00	
6	5	30	¾	.04		—	182.31	0.19	"	1[illegible]	[illegible]3	1[illegible]	40	25.00	
7	5	30	¾	.05		—	178.46	0.15		1[illegible]	13	5[illegible]	[illegible]	[illegible]8.00	
8	4½	.27	¾	.04		—	179.34	0.75		1[illegible]	43	53	52	28.00	
9	6	.36	¾	.05		—	176.60	0.[illegible]	"	12	13	[illegible]2	1[illegible]	[illegible].00	
10	5	30	[illegible]	.02			[illegible]51.[illegible]	0.4[illegible]	"	1	1[illegible]	55	40	[illegible].50	
11	5	30	¾	.01			18[illegible]	0.[illegible]2		11	3[illegible]	4	36	[illegible]	
12	5	30	¾	.05		—	1[illegible]	0.31	"	12	39	5	[illegible]2	28.00	
13	6	3[illegible]	¾	.04			1[illegible]3[illegible]	0.9	" "	9¼	[illegible]3	[illegible]3	40	28.00	
14	[illegible]	[illegible]	¾	.05			1[illegible]	0.04	"	[illegible]	4[illegible]	4	[illegible]	[illegible].50	
15	[illegible]	3	¾	.04		—	1[illegible]4.6[illegible]	[illegible]	"	1[illegible]	41	52	[illegible]	30.00	
16	3[illegible]	[illegible]	¾	.0[illegible]			1[illegible]6.0	0.30	" "	1	43	5[illegible]	60	29.5[illegible]	
17	4	[illegible]4	[illegible]	.03			[illegible]	0.3[illegible]	" "	—		[illegible]	40	2[illegible].50	Chipping rock u[illegible] cutting edge. Caisson [illegible]
18	4	2	1	.00		—	[illegible]	[illegible]		72[illegible]	46	45	30	[illegible]9.50	[illegible] bec[illegible]
19	4	[illegible]	½	.03			1[illegible]9.8[illegible]					—	34	[illegible]9.50	
20	1	2[illegible]	½	.03			[illegible]4.8						31	[illegible].50	
21	3	15	½	.03	[illegible]	[illegible]	[illegible]50.[illegible]			—			30	2[illegible].50	
22	3	1[illegible]	[illegible]	.12			[illegible]						6	[illegible]9.50	Air compressor stopped at 4 P.M.
	—	—	—	—	—	—	3.06								
		[illegible]1.58		[illegible].2[illegible]		0.[illegible]	168.0[illegible]								

Other expenses charged to Sinking . . . 111[illegible]3

$3[illegible]

APPENDIX E.

SPECIFICATIONS FOR SUPERSTRUCTURE.

GENERAL DESCRIPTION.

The Superstructure will consist of four through spans and six deck spans, all built to carry two railroad tracks and two independent roadways.

Each deck span will be 120 feet $7\frac{1}{2}$ inches long between centers of end pins, divided into five panels of 24 feet $1\frac{1}{2}$ inches each, the trusses being 18 feet deep and placed 18 feet 6 inches apart between centers. In two spans the expansion for temperature will be provided for by steel rollers: the other four spans will rest at one end on iron bents, with a rocking pin bearing at top and bottom. The deck spans will be entirely of wrought iron, except the pins, rollers, and bearing plates, which will be of steel, and the wall plate pedestals, which will be of cast iron. Each span will contain approximately 308,000 pounds of wrought iron and steel, and each bent 27,000 pounds.

Each through span will be 246 feet $2\frac{7}{8}$ inches long between centers of end pins, divided into eleven panels of 22 feet $4\frac{5}{8}$ inches each. The trusses will be 40 feet deep and placed 28 feet 6 inches apart between centers. The roadways will be carried on cantilever arms outside the trusses. The top chord, end posts, the eye-bars of the bottom chord, and a portion of the main ties, the bolsters, rollers, bearing plates, and pins will be of steel; all other parts will be of wrought iron except the wall plate pedestals and ornamental work, which will be cast. Each span will contain approximately 392,000 pounds of steel, 526,000 pounds of wrought iron, and 27,000 pounds of cast iron.

The total estimated weight of the entire structure is approximately 5,700,000 pounds.

PLANS.

Full detail plans, showing all dimensions, will be furnished by the Engineer. The work shall be built in all respects according to these plans. The contractor, however, will be expected to verify the correctness of the plans, and will be required to make any changes in the work which are necessitated by errors in these plans, without extra charge, when such errors could be discovered by an inspection of the plans.

The dimensions given for rivets on the plans are the diameter of the rivet before driving; the rivet hole will be $\frac{1}{16}$ of an inch larger than this diameter, unless otherwise specified.

MATERIALS.

All materials shall be subject to inspection at all times during their manufacture, and the Engineer and his inspectors shall be allowed free access to any of the works in which any portion of the material is made. Timely notice shall be given to the Engineer so that his inspectors may be on hand.

Steel.—The steel used will be of two classes: High steel, which will be used in the compression members, bolsters, bearing plates, pins, and rollers; and Low steel, which shall be used for tension members and rivets. The amount of phosphorus shall not exceed $\frac{8}{100}$ of one per cent.

No special method of manufacture will be insisted on, provided the steel meets the conditions of the specifications, but all steel manufactured for one class of work shall be made by the same process and at the same works. A small ingot shall be cast from every melt when the melt is half poured, and a sample bar $\frac{3}{4}$ of an inch in diameter shall be rolled from this ingot; the tests shall be made on this bar in its natural state, except the second bending test for low steel, which shall be made on this bar after heating to a bright red and immersing in water of a temperature not higher than 100° Fahr.; if the test bar fails to meet the requirements of the laboratory tests, the whole charge shall be rejected.

The laboratory tests of high steel made on the sample bars $\frac{3}{4}$ of an inch in diameter shall show an elastic limit of not less than 50,000 pounds, an ultimate strength of not less than 80,000 pounds per square inch, an elongation of at least 15 per cent in a length of 8 inches, and a reduced area of at least 35 per cent at the point of fracture. In a bending test, the sample bar shall bend 180° around its own diameter without showing crack or flaw.

The laboratory tests of low steel made on the sample bar $\frac{3}{4}$ of an inch in diameter shall show an elastic limit of not less than 40,000 pounds, an ultimate strength of not less than 70,000 pounds per square inch, an elongation of at least 18 per cent in a length of 8 inches, and a reduction of at least 42 per cent at the point of fracture. In a bending test the sample bar shall bend 180°, and be set back against itself without showing crack or flaw; in a second bending test the quenched bar shall bend 180° around its own diameter without cracking. The softest melts shall be selected for rivets, and no fixed elastic limit nor ultimate strength will be insisted on.

Facilities for testing the sample bars shall be furnished by the contractor at a point convenient to the steel works, and the tests shall be made at the expense of the contractor and under the direction of the Engineer.

The steel plates for compression members shall be rolled in a universal mill. All sheared edges on steel work shall be subsequently planed.

Steel for pins shall be sound and entirely free from piping.

Wrought Iron. The iron used in tension members shall be double-refined iron, rolled twice from the puddled bar. Small samples, having a minimum length of 8 inches, shall be furnished by the contractor for testing, as directed by the Engineer; these samples shall show an elastic limit of at least 26,000 pounds, and an ultimate strength of at least 50,000 pounds per square inch, shall elongate at least 15 per cent, and shall show a reduced area of at least 25 per cent at the point of fracture. The fracture shall be of uniform fibrous character, free from crystalline appearance.

Small samples, having a minimum length of 8 inches, shall be furnished by the contractor from the iron used in shapes, plates and other miscellaneous forms, as directed by the Engineer; these samples shall show an elastic limit of at least 24,000 pounds and an ultimate strength of at least 47,000 pounds per square inch, shall elongate at least 10 per cent before breaking and show a reduction of area of at least 15 per cent at the point of fracture. In plates more than 30 inches wide an elongation of 8 per cent and a reduction of 12 per cent at the point of fracture will be considered satisfactory.

Cast Iron shall be of the best quality of tough, gray iron.

RIVETED WORK.

The riveted steel work of the trusses shall be punched with holes not larger than $\frac{13}{16}$ of an inch in diameter; the several parts of each member shall then be assembled, and the holes shall be reamed to $\frac{15}{16}$ of an inch in diameter, at least $\frac{1}{16}$ of an inch being taken out all around; the sharp edge of the reamed hole shall be trimmed so as to make a slight fillet under the rivet head, and the pieces shall be riveted together without taking apart. All rivets in steel members shall be of steel; they shall be of such size that they will fill the hole before driving, and, whenever possible, shall be driven by power. All bearing surfaces shall be truly faced. The chord pieces shall be fitted together in the shop in lengths of at least five panels, and marked; when so fitted there shall be no perceptible wind in the length laid out. The pin holes shall be bored truly, so as to be at exact distances, parallel with one another and at right angles to the axis of the member.

All wrought-iron work shall be punched accurately with holes $\frac{1}{16}$ of an inch larger than the size of the rivet, and when put together a cold rivet shall pass through every hole without reaming. So far as possible all rivets shall be driven by power. The holes for the rivets connecting the floor-beams with the posts and bolsters, and the stringers with the floor-beams, and, in general, the holes for all rivets which must be driven after erection, shall be accurately drilled to an iron templet. The holes for the rivets connecting the floor-beams with the posts shall be 1 inch in diameter, and the rivets of corresponding diameter. The pin holes in the vertical posts shall be truly parallel with one another, and at right angles to the axis of the posts.

Power riveters shall be direct acting machines, capable of exerting a yielding pressure and holding on to the rivet when the upsetting is completed.

All plates, angles, and channels shall be carefully straightened before they are laid out; the rivet holes shall be carefully spaced in truly straight lines; the rivet heads shall be of hemispherical pattern, and the work shall be finished in a neat and workmanlike manner. Surfaces in contact shall be oiled before they are put together.

FORGED WORK.

The heads of steel eye-bars shall be formed by upsetting and forging into shape by such process as may be accepted by the Engineer. No welds will be allowed. After the working is completed, the bars shall be annealed by heating them to a uniform dark-red heat throughout their entire length and allowing them to cool slowly.

The heads of iron eye-bars and the enlarged ends of screws in laterals and counters shall be formed by upsetting or by upsetting and welding by a process acceptable to the Engineer. Welds in the body of the bar will not be allowed.

The heads of iron eye-bars shall be made of the dimensions shown on the drawings. The form of the heads of steel eye-bars may be modified to suit the process in use at the contractor's works, but the contractor will be required to furnish evidence that the form of head which he prefers to adopt is such that it may be relied upon to break the body of the bar, and the acceptance of such modified form of head will not relieve the contractor from any responsibility as to the result of the tests.

Steel eye-bars of the same section will be accepted in place of iron eye-bars at a price not exceeding that of the iron.

MACHINE WORK.

The bearing surfaces in the top chord shall be truly faced. The ends of the stringers and of the floor-beams shall be squared in a rotary facer. All surfaces so designated on the plans shall be planed.

All pins shall be accurately turned to a gauge, and shall be of full size throughout; pin holes shall be bored to fit the pins, with a play not exceeding $\frac{1}{50}$ of an inch. These clauses apply to all lateral connections as well as to those of the main trusses. Pins shall be supplied with pilot nuts for use during erection, four for each size of pin.

All screws shall have a truncated V thread, United States standard sizes.

TESTS OF FULL-SIZED BARS.

Ten full-sized steel eye-bars of sections and lengths used in the actual work shall be selected by the inspector for testing; each of these full-sized bars shall be strained till an elongation of 10 per cent is obtained, and if possible broken; if broken, the fracture shall occur in the body of the bar, and shall show a uniform and ductile quality of material.

Six full-sized iron eye-bars of sections and lengths used in the actual work shall be selected by the inspector for testing; each of these full-sized bars shall be strained till an elongation of 10 per cent is obtained, and if possible broken; if broken, the fracture shall occur in the body of the bar, and shall show a uniform, fibrous material.

The contractor will be required to furnish facilities for testing the full-sized bars within a reasonable distance of his works. Should the contractor be unable to furnish such facilities, he shall be required to furnish bars of 20 per cent larger section than those called for, without charge for the increased weight.

The full-sized bars shall be selected from time to time as the work proceeds, the last bar not to be selected till all the eye-bars are manufactured. The tests shall be made from time to time as the bars are selected. When three bars have been tested, the bars manufactured up to the time of the selection of these three test bars shall be accepted or rejected as the result of such tests, and the same shall be done again when three more bars are tested. In the tests, the failure of one bar to develop a stretch of 10 per cent before breaking shall be sufficient reason for rejecting the whole lot; but a failure to break in the body of the bar shall not be a sufficient ground for condemnation if it does not occur in more than one third of the bars tested. Should the contractor on the first attempt fail to make bars coming up to the required specifications, the Engineer may order bars of 20 per cent larger section than the plans call for, to be furnished by the contractor without charge for the increased weight.

MISCELLANEOUS.

All workmanship and material, whether particularly specified or not, must be of the best kind now in use in first-class bridge work. Flaws, ragged edges, surface imperfections, or irregular shapes will be sufficient ground for rejection; rough and irregularly finished work will not be accepted.

Machine-finished surfaces shall be coated with white lead and tallow before shipment; all other parts shall be given a coat of hot boiled linseed oil.

TERMS.

Monthly estimates will be made at the end of each month for the work done during that month. In these monthly estimates, the material delivered at the contractor's shop, but not manufactured, shall be estimated at 50 per cent of the contract price for finished material in Chicago, and manufactured material at 75 per cent of the contract price for finished material in Chicago. Payments will be made on or about the 15th day of the following month, according to these estimates, deducting from the amount of the same 10 per cent as security, to be held until the completion of the entire contract.

No material will be paid for which does not form a part of the permanent structure.

All expense of testing shall be borne by the contractor.

TIME

The first deck span, with one bent, shall be completed and ready for shipment not later than April 1, 1886, and the other deck spans and bents shall follow at intervals of two weeks each. The first through span shall be completed and ready for shipment by June 1, 1886. The other three through spans will be required in November, 1886, and January and March, 1887, respectively.

The railroad company may exact a penalty not exceeding $150 per day for failure to complete the work in these specified times.

PROPOSALS

Separate proposals should be made for the deck spans (including bents) and the through spans.

The price for the deck spans should be a uniform price per pound for all classes of material.

Prices for the through spans should be by the pound at separate rates for steel, wrought iron, and cast iron.

The prices shall include material, and all patterns and other work of every description, and are to be on the basis of finished material delivered on cars at Chicago ready for shipment to Council Bluffs.

Each proposal will be required to state what class of steel it is proposed to use, and what facilities the bidder can furnish for testing full-sized tension members, and the process by which and place where eye-bars will be manufactured.

The right is reserved to accept separate proposals for the deck spans and the through spans, to reject all bids, and to award the contract to other than the lowest bidder.

GEORGE S. MORISON,
Chief Engineer Omaha Bridge.

NEW YORK, December 1, 1885

APPENDIX F.

TESTS OF STEEL EYE-BARS.

TESTS ON FULL-SIZED EYE-BARS. Dimensions,—Inches. Original. Nominal. Width.	Thickness.	Actual. Length c. to c.	Actual. Width.	Actual. Thickness.	After Testing. Width.	After Testing. Thickness.	Results of Mechanical Tests. Reduction of Area. Per cent.	Extension. Gauged Length. Inches.	Extension. Per cent.	Elastic Limit. Lbs. per sq. in.	Maximum Load. Lbs. per sq. in.	Place of Fracture.	TESTS ON SAMPLE BARS FROM SAME MELTS. Diameters. Original. Inches.	Diameters. After Testing. Inches.	Reduction. Per cent.	Extension. Per cent.	Elastic Limit. Lbs. per sq. inch.	Maximum Load Lbs. per sq. inch.	Per cent of Phosphorus.	Heat Number.
6	1 1/16	268.69	6.00	1.062	4.562	0.75	46.30	240	13.85	39,560	63,215	Body	—		—		—	—	—	84 L
6	1¼	268.60	6.00	1.250	4.500	0.875	47.50	240	15.65	36,400	58,065	"	—	—		-		—	—	84 E
5	13/16	268.63	5.00	0.677	3.937	0.50	51.50	240	14.80	40,320	59,520	"	—	—			—		—	84 E
7	1⅜	268.65	7.00	1.36	5.31	0.78	56.30	228	16.00	36,630	59,980	"	74	524	49.87	27.50	43,710	65,430	0.063	5645
7	1½	268.65	7.00	1.50	—	—	—	228	—	38,840	46,030	Head	742	545	46.35	24.75	45,350	68,800	0.067	5583
7	1⅝	268.65	7.00	1.62	5.22	0.96	55.80	228	11.80	36,510	60,250	Body	732	528	47.96	24.50	44,390	68,230	0.074	5632
7	1½	268.65	7.04	1.48	5.44	1.00	47.70	228	15.70	36,010	60,090	"	732	528	47.96	24.50	44,390	68,230	0.074	5632
7	1¾	268.63	7.00	1.76	—	—	—	228	—	37,240	58,430	Head	734	539	46.07	25.25	46,090	70,150	0.076	5634
7	1⅝	268.65	7.05	1.59	5.49	1.15	43.60	228	11.60	40,390	67,130	Body	737	546	45.1[illegible]	24.75	44,[illegible]50	70,960	—	5654
7	1⅝	360.41	7.02	1.62	5.45	1.09	47.75	324	10.60	38,560	65,832	"	731	545	44.42	26.00	45,320	70,620	0.075	5663
6	1 5/16	360.41	6.01	1.32	4.53	0.80	54.31	324	16.40	35,480	60,930	"	736	500	53.86	26.00	43,730	67,460	0.075	5569
7	1⅝	360.41	7.00	1.63	5.83	1.27	35.10	324	11.50	37,180	62,380	"	727	501	52.64	26.50	43,250	67,600	0.062	5656
7	1½	268.63	7.00	1.50	6.74	1.42	8.84	240	6.66	37,300	58,270	"	742	545	46.35	24.75	45,350	68,800	0.067	5583
7	1½	268.63	7.03	1.51	5.20	0.91	55.42	240	13.90	36,510	60,720	"	742	545	46.35	24.75	45,350	68,800	0.067	5583
7	1¾	268.63	6.98	1.73	—	—	—	240	6.30	34,630	56,080	Head	739	545	45.61	25.75	45,370	69,510	0.076	5634
7	1¾	268.63	7.02	1.75	5.25	1.07	54.26	240	17.30	36,190	62,920	Body	736	508	52.36	27.25	44,900	68,980	0.067	5644
7	1½	268.65	6.95	1.50	5.46	1.12	41.30	240	13.00	42,760	73,370	"	—	—			—	—	—	42027
7	1¼	268.65	6.92	1.22	—	—	41.60	240	14.30	45,180	76,350	"	—				—		—	42027

APPENDIX G.

LETTER TO MR. T. J. POTTER.

CHICAGO, ILL., Nov. 3, 1887

THOMAS J. POTTER, Esq.,
Vice-President Union Pacific R'y., Omaha, Neb.

DEAR SIR, — I have directed Mr. Duryea to turn over the Omaha Bridge to Mr. Bogue on the 10th; this completing my connection with the work, excepting such work as remains to be done in preparing my final report upon the same.

There is a small amount of work which is properly a portion of the construction of the bridge, but which is not yet done.

The principal part of this consists in removing the cylinders of old piers. The eight cylinders composing the four piers which come under the through spans of the new bridge have all been cleared out, and the joints disconnected at least five feet below extreme low water. The cylinders of Piers IV. and V. are embedded so deeply in riprap and other surrounding material that it would be difficult to remove them. Probably after a few floods they can be taken out more easily. The cylinders of Pier III. have both been removed, as was supposed; but it seems that the lower section of one of these cylinders was broken off in the removal, and remains in position. After another season of high water I think a careful examination should be made here; and if anything is found above a safe height, I think there will be no difficulty in overturning it. In Pier II. one cylinder has been thoroughly removed; the other cylinder cannot be removed until the debris around it is washed away; this will probably occur next year, when this cylinder can probably be tipped over and removed.

The east approach to the bridge is a trestle 1,000 feet long, taking the place of four spans of the original bridge. The whole of this trestle has been filled with earth to a height above the high water of 1881, the earth embankment being made the full width of the base of a permanent bank. The easterly quarter of this trestle is an old trestle repaired and enlarged; the remainder is new, but it was all built as a temporary piece of work, it being expected that the whole would be filled before this. In consequence of the action taken by the City of Council Bluffs, and under the direction of Mr. Calloway, this filling was temporarily abandoned. I should recommend that it be done with as little delay as is consistent with economy. The danger of fire in a trestle of this kind is too great a risk to assume.

The estimated quantity of earth required to fill this trestle is 150,000 yards, the cost of which, if done with strict economy, might be kept inside of 20 cents; I should, however, prefer to estimate it at 25 cents. Moreover, as it is likely that some settlement will occur as the filling proceeds, I think the sum appropriated for this filling should not be less than $40,000.

Some years ago the construction of a levee above Council Bluffs was begun. This is the only sure way of protecting the low bottom-land between the town and the river from overflow in extreme floods. I have had a survey made of the route on which I think this levee should be extended to the bridge, and its cost would not be large. It seems to me important that it should be built at an early date; and the advantage of it would be so great to the Union Pacific, as the owner of a large portion of the low bottom-land, that your company could with propriety pay at least one half.

In connection with this levee it has seemed to me that the shore line of the river in front of the town of Omaha would be rectified to a very good advantage, this rectification being brought about by building a dike from the west shore above the water works, and gradually extending it towards the bridge line, and so reclaiming something like two hundred acres of land which would be very valuable. The work would be a matter of considerable expense, and if done economically would occupy two or three years. If the proposed roadway bridge at the foot of Douglas Street is built on the location proposed, it will defeat this scheme; if such bridge is not built I believe this rectification matter to be one of great importance to your company.

The carriage roadways are completed and ready for traffic, and the west approach has been paved from the toll-house to the bridge. Outside of the two toll-houses no paving has been done, but the approaches are graded, and are in good condition for use except in very wet weather. The streets are not graded to a connection with these approaches on either side, and it seems to me important that this should be done. The location of the west approach was a compromise location; it connects with the city street a little east of the intersection of Sixth and Leavenworth Streets. The location which I selected would have terminated at the intersection of Seventh and Marcy Streets, at the north end of the large bridge which your company is building across Seventh Street; in my judgment this is the true location for this approach, and I believe it would be worth while to have it graded now.

The two roadways are adapted to carriage travel and to foot travel; street railway tracks can be laid at any time without difficulty, and the roadways can be adapted to a cable road at small expense whenever it is thought expedient. While the position of these roadways is undoubtedly such that horses unaccustomed to the situation would be frightened by trains, the position of the roadways between two strong fences is such that the frightened horses could do no harm, and after they had been used a short time, the number of horses that would be frightened would be comparatively small. I do not think the danger of driving on these roadways is as great as the danger of driving in one of the New York streets in which an elevated railroad is built. A wooden fence six and a half feet high above the roadway floor, which could be built at any time without difficulty, would shut out the view of trains from horses on the roadways. It may be expedient to build such a fence, but I should prefer to use the bridge first without it, simply making a regulation that no whistle should be blown, and no steam allowed to escape, while trains are on the bridge. It might also be expedient to give notice that at certain hours of the day — say half an hour in the morning, and half an hour in the afternoon — the bridge would be kept free from railroad trains.

I should recommend that the roadways be opened for traffic as early as can conveniently be done; and my judgment would be to fix the tolls at about one half the tolls charged on the ferry trains, and that a notice be put up at each toll-house stating that at certain designated times the bridge would be kept clear of trains, and that persons whose horses were unaccustomed to locomotives had better cross at those hours; with such a notice any responsibility for accidents from frightened horses would be thrown upon the owners, and the bridge would be open for horses accustomed to trains at all times.

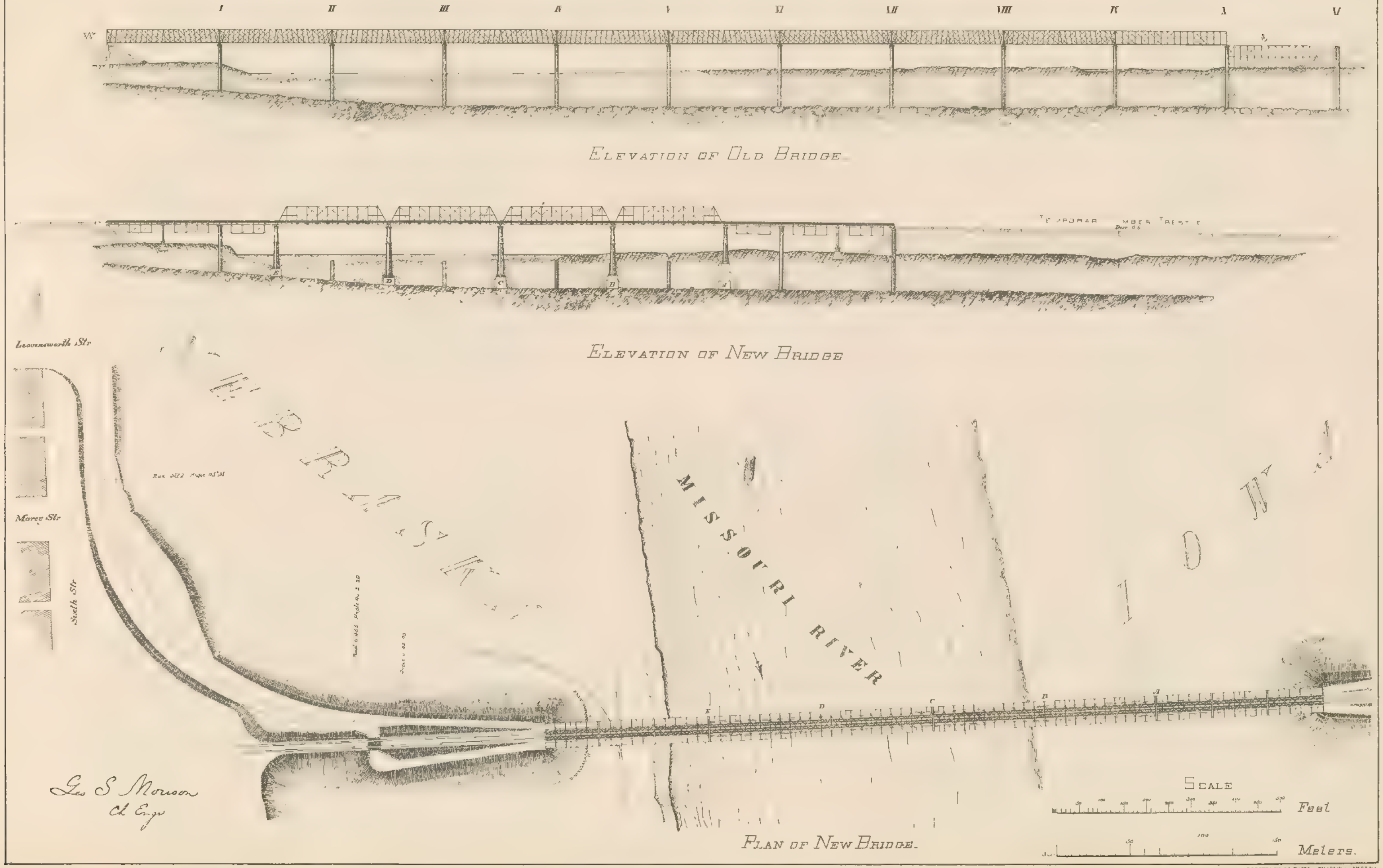
If there are any points on which you desire additional information from me, I shall be very glad to give it. I regret exceedingly that I failed to see you the last time I was in Omaha, and that my arrangements will prevent my visiting Omaha again before spring.

Yours truly,

GEORGE S. MORISON,
Chief Engineer Omaha Bridge.

Plate 1

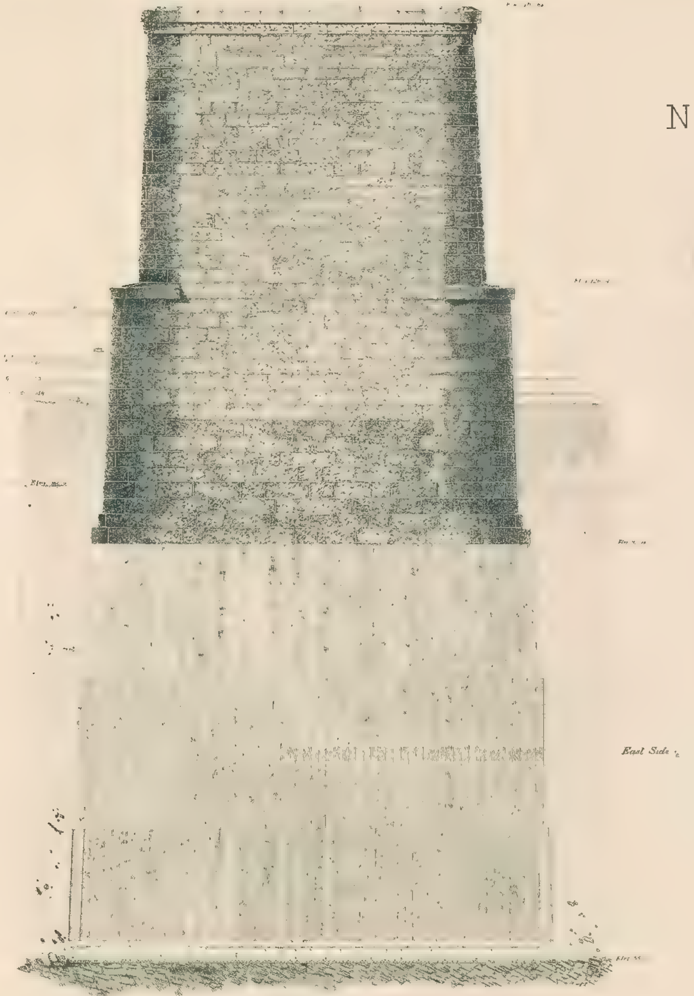
U.P.R.
NEW OMAHA BRIDGE
GENERAL ELEVATIONS AND PLAN



UPR

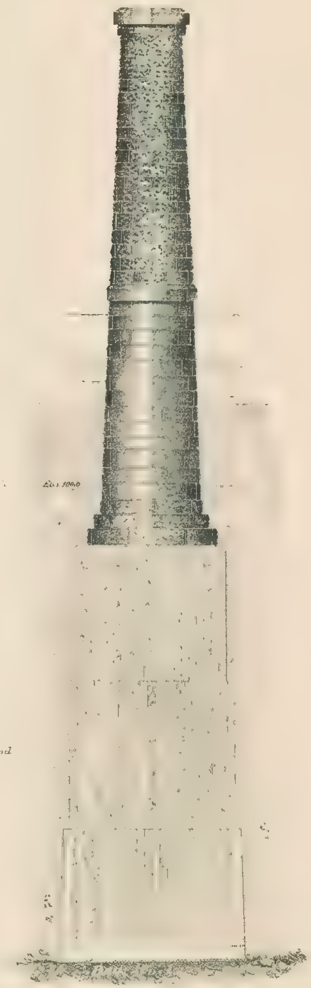
NEW OMAHA BRIDGE.

Scale:



PIER A.
Side Elevation

PIER A.
Plan



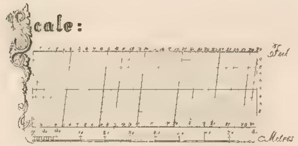
PIER A.
End Elevation

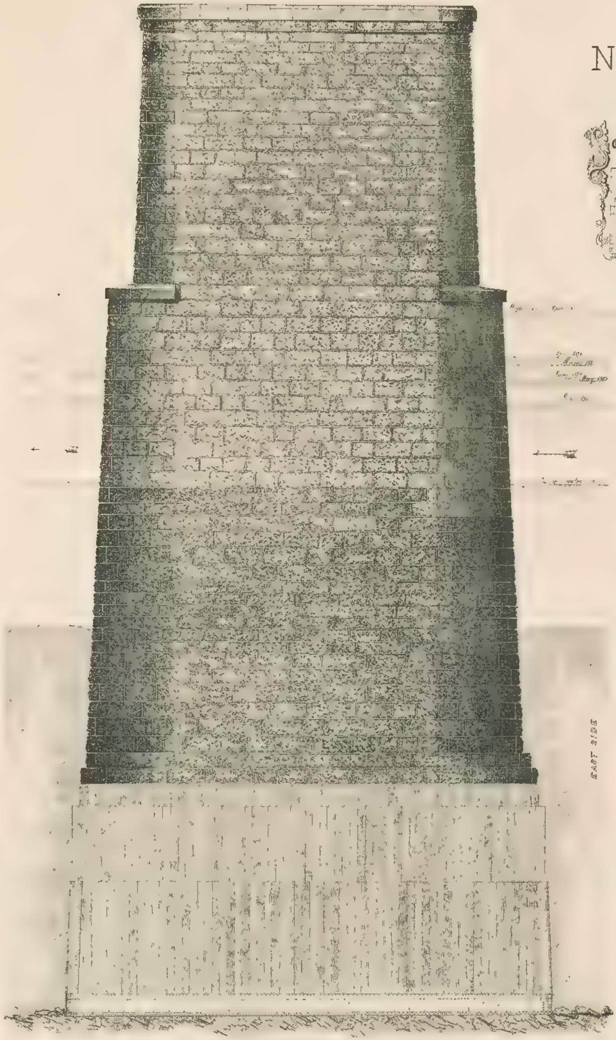
Geo. S. Morison
Ch. Engr.

Plate 3

UPR
NEW OMAHA BRIDGE.

Scale:



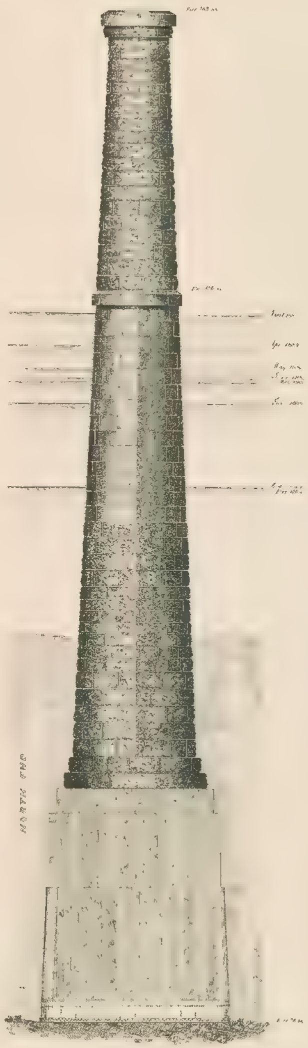


PIER B.

Plan

PIER B.

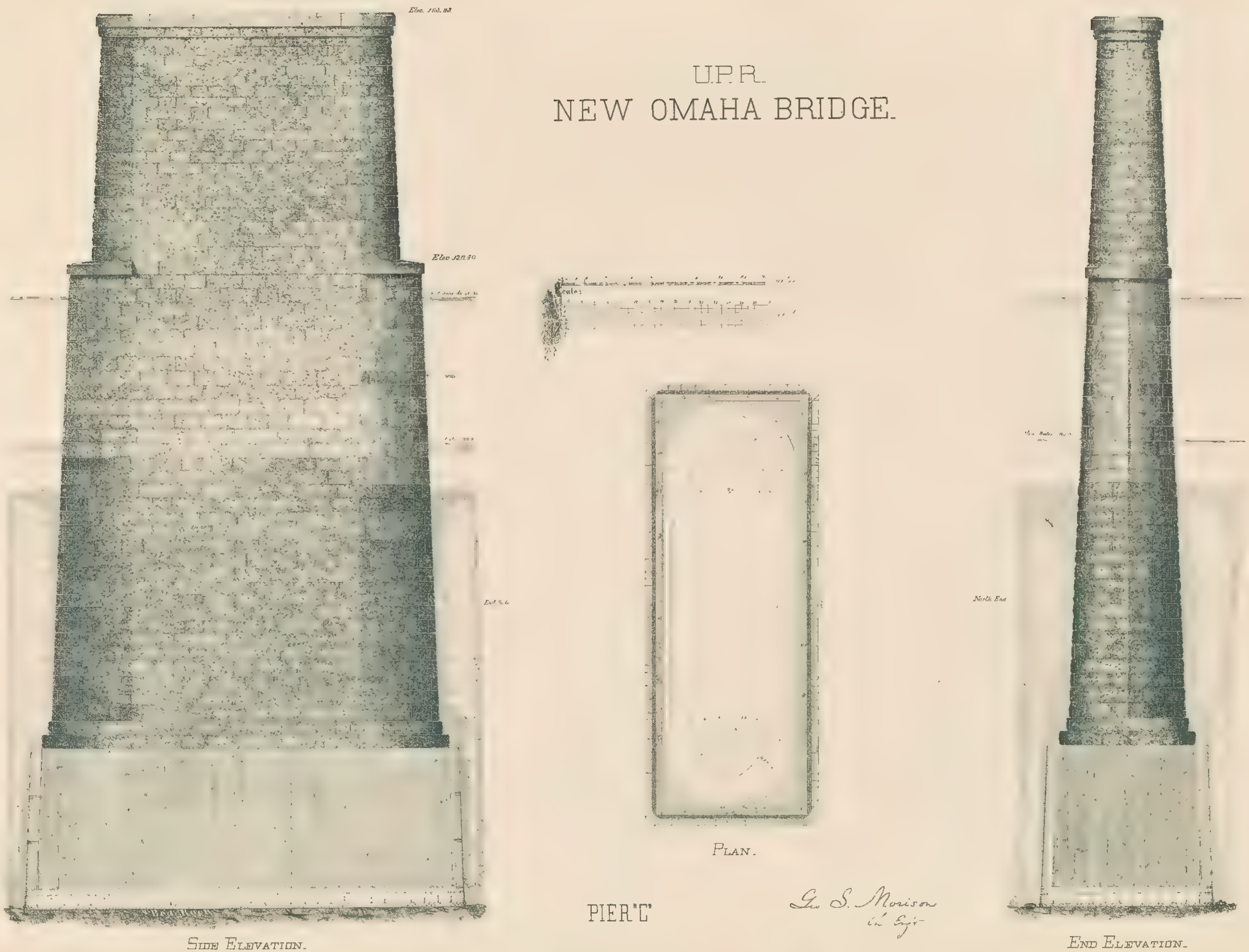
G. S. Morison
Ch. Engr



PIER B.

ROBERT A. WELCKE PHOTO. LITH. 178 WILLIAM ST. N.Y.

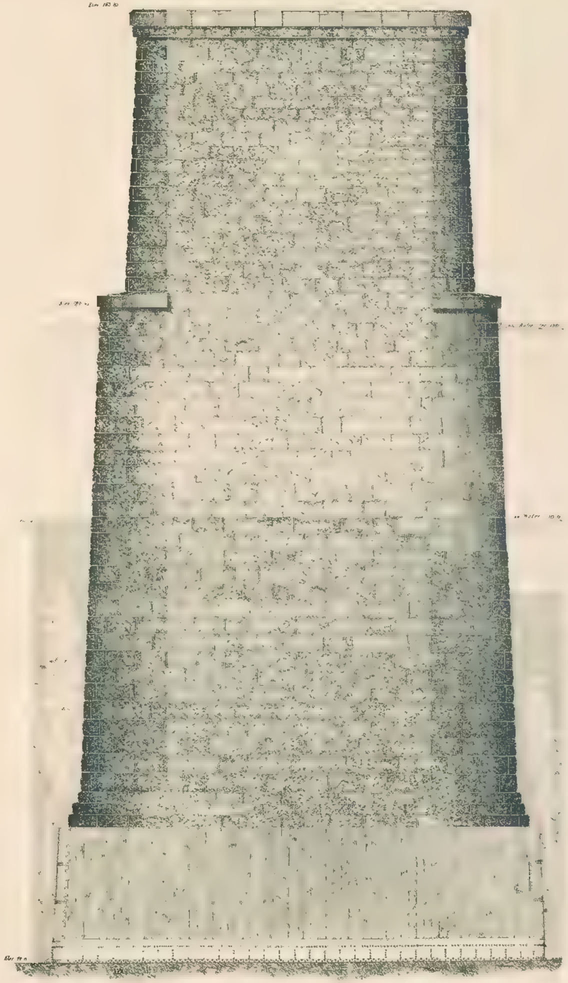
PLATE 4.


U.P.R.
NEW OMAHA BRIDGE.
Side Elevation.
Plan.
End Elevation.
PIER "C"
Geo. S. Morison
Ch. Engr.
North End

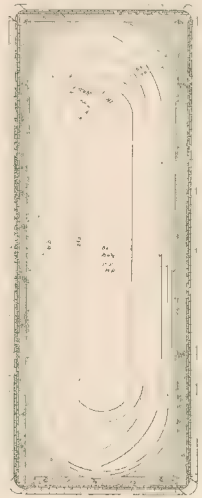
U.P.R.

NEW OMAHA BRIDGE.

Scale:



SIDE ELEVATION.



PLAN.

END ELEVATION.

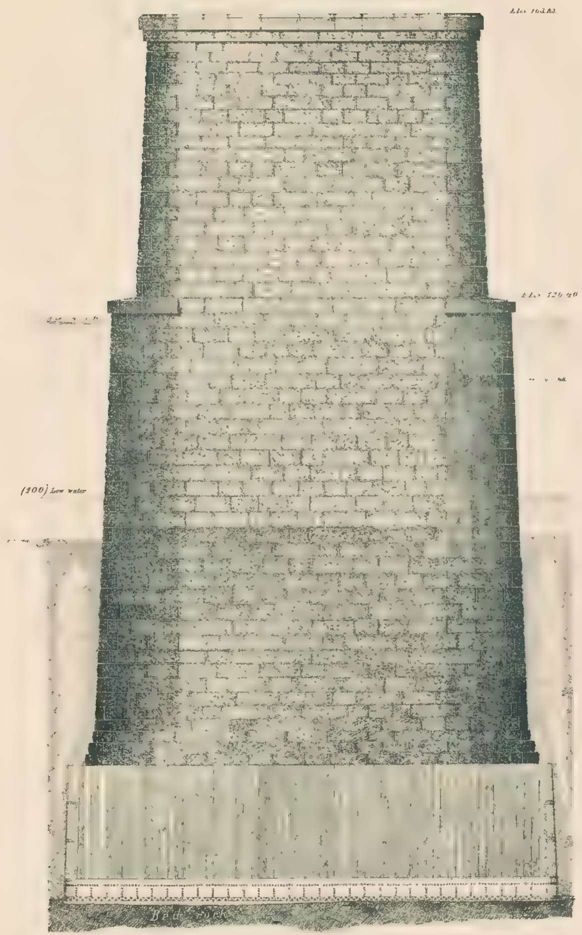
PIER "D"

Geo. S Morison
Ch. Eng'r

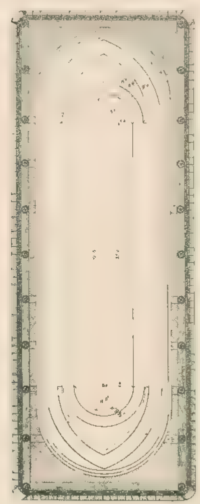
PLATE 6

UPR
NEW OMAHA BRIDGE.

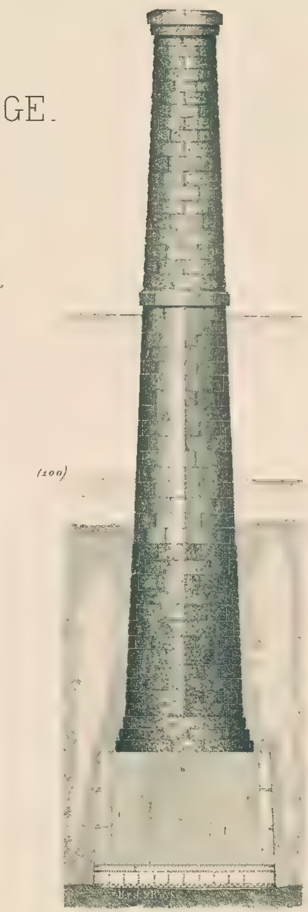
Scale:



SIDE ELEVATION.
(East side)



PLAN.

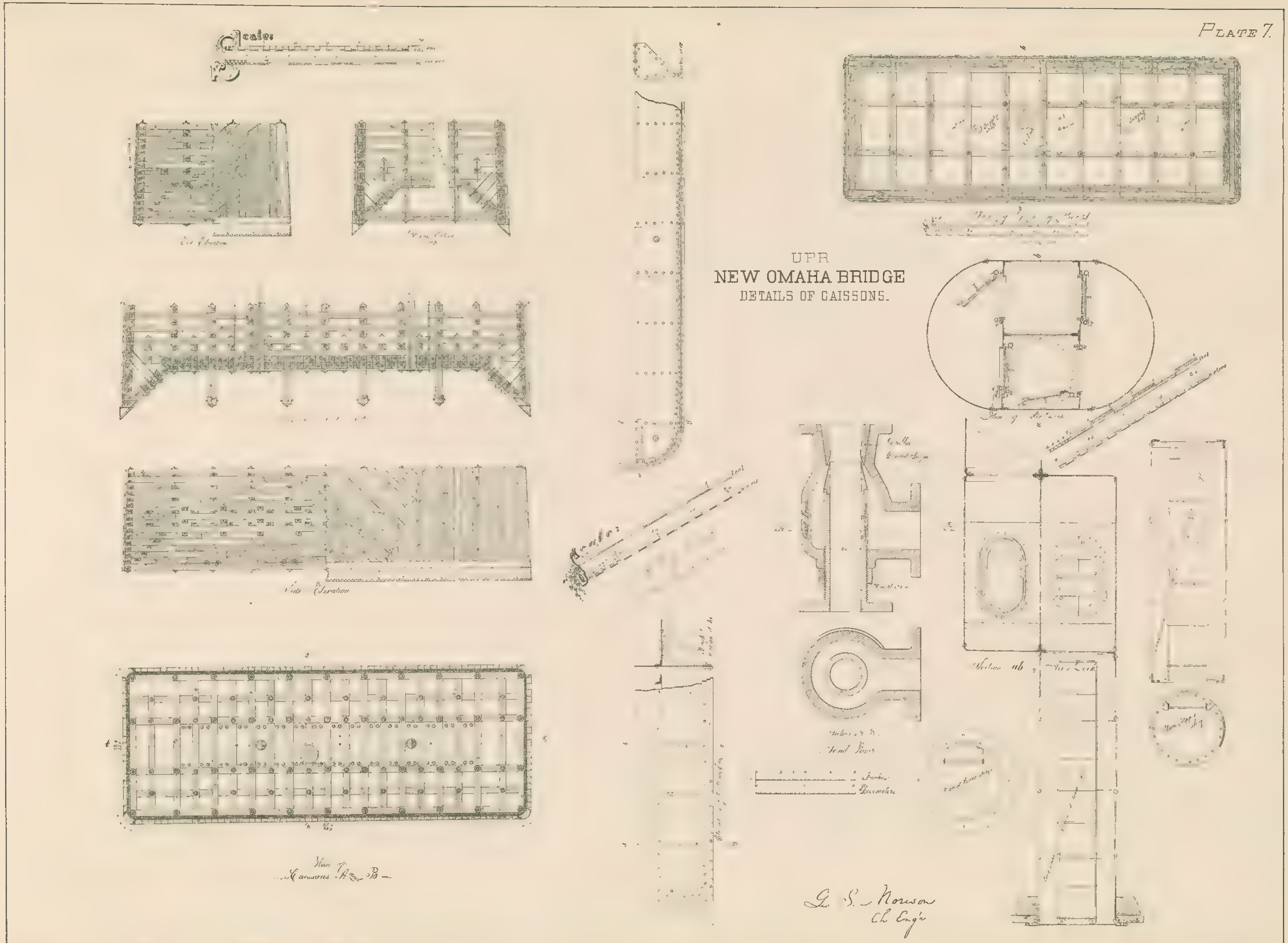


END ELEVATION.
(North end)

PIER "E".

Geo. S. Morison
Ch. Eng'r

ROBERT A. WELKE PHOTO. LITH. 78 WILLIAM ST. N.Y.

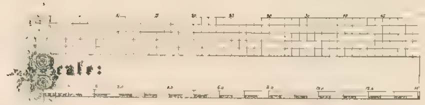


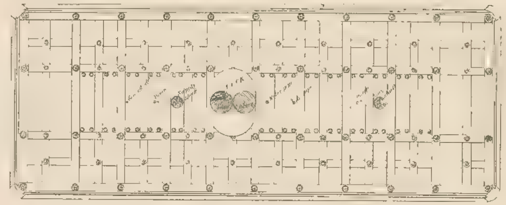
ROBERTS & WELCKE PHOTO L'TH. 178 WILLIAM ST N.Y.

U.P.R.

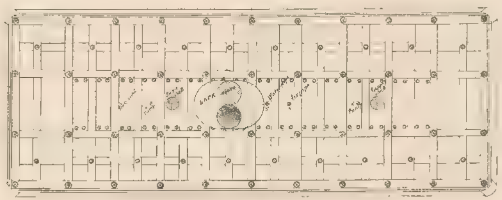
NEW OMAHA BRIDGE

ARRANGEMENT OF AIR-LOCKS, SHAFTS AND PIPES

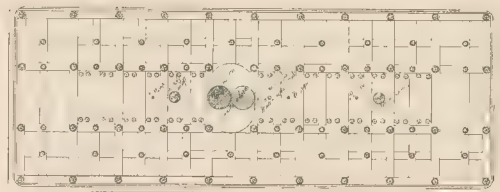




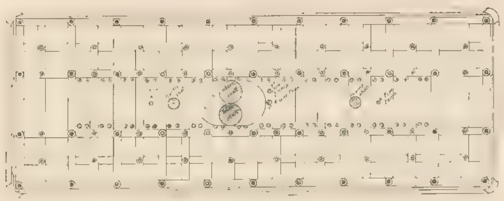
Pier C.



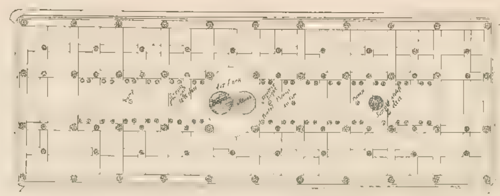
Pier B.



Pier D.



Pier A.



Pier C.

Geo. S. Morison
Ch. Engr

PLATE 9

U.P.R.

NEW OMAHA BRIDGE

PLAN SHOWING POSITION OF CAISSONS ON ROCK

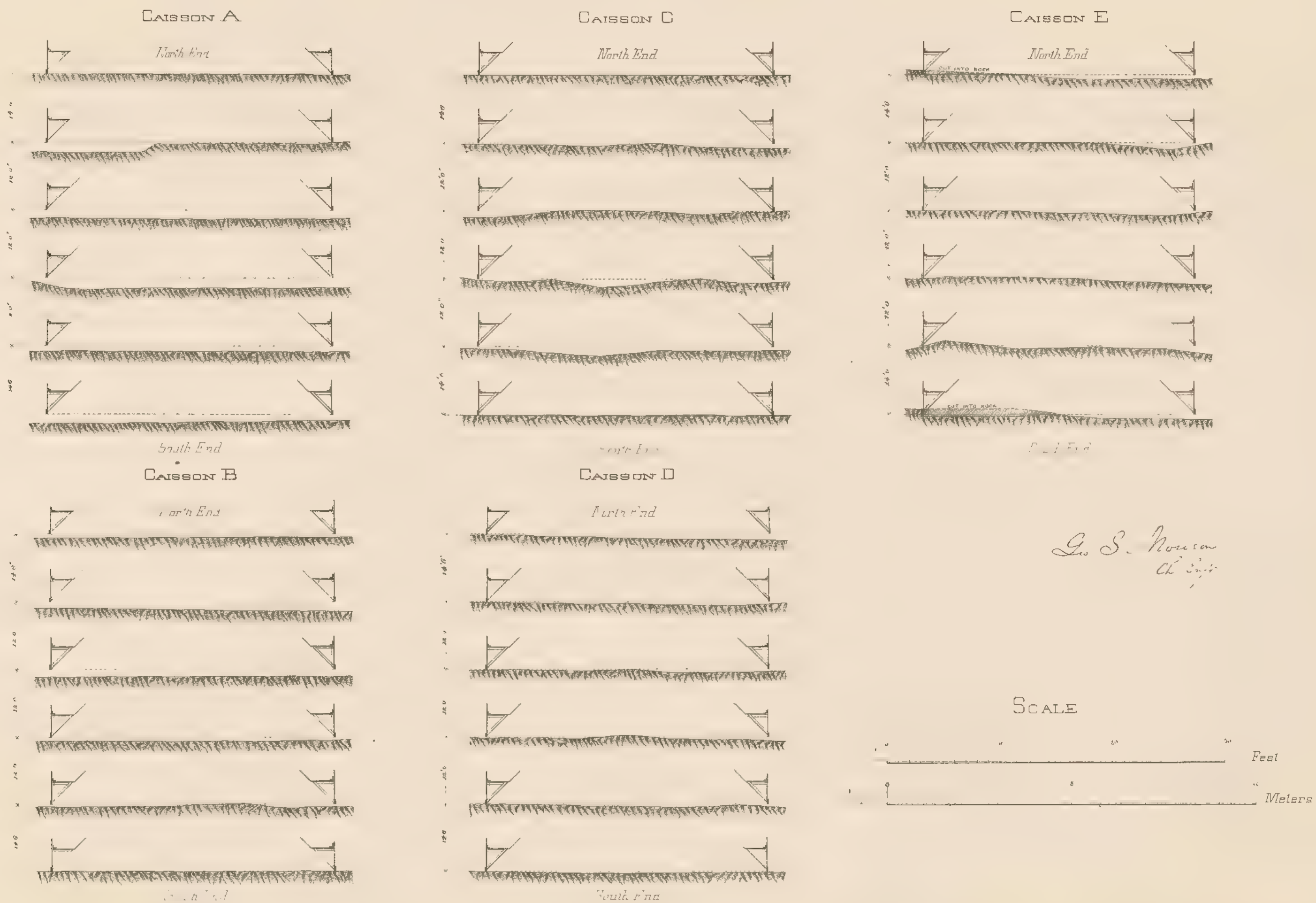


Plate 10

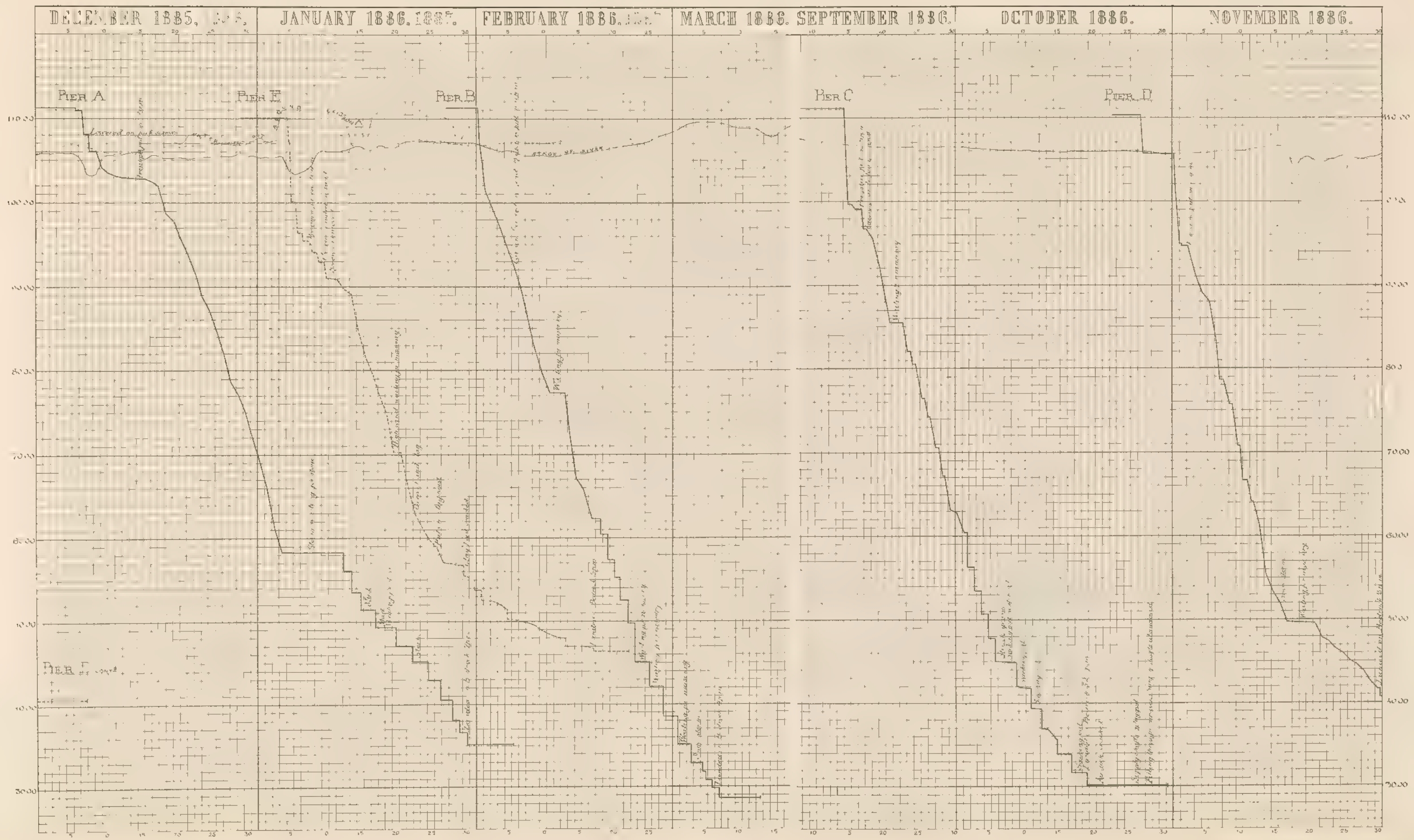
U.P.R.

NEW OMAHA BRIDGE

Diagram showing rate of progress in Sinking Caissons

Geo S. Morison
Ch. Eng.

Note! Dotted lines show Stage of River & Sinking performed during December 1886 January & February 1887



ROBERT A. WELKE PHOTO. LITH. 78 WILLIAM ST. N.Y.

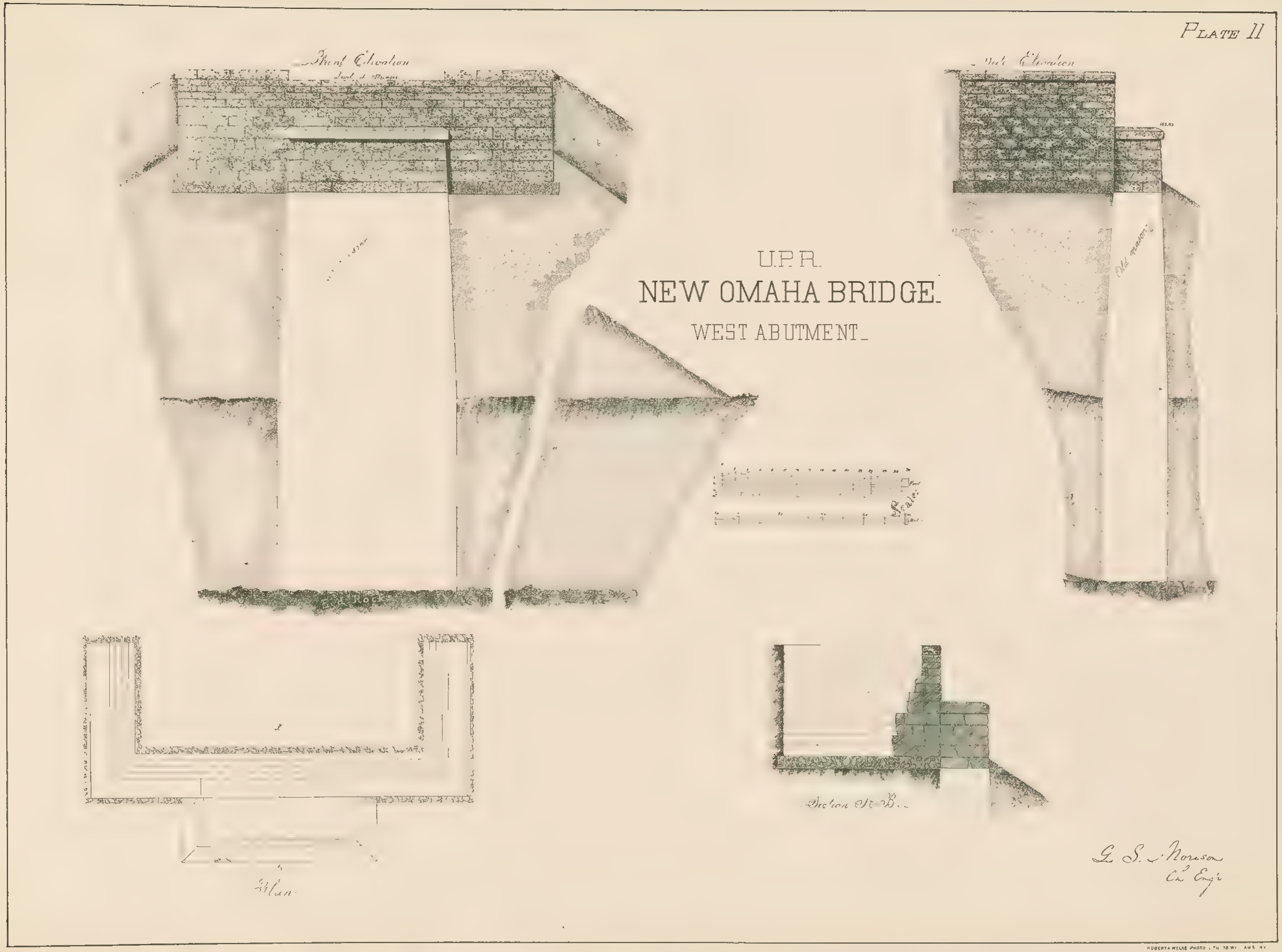
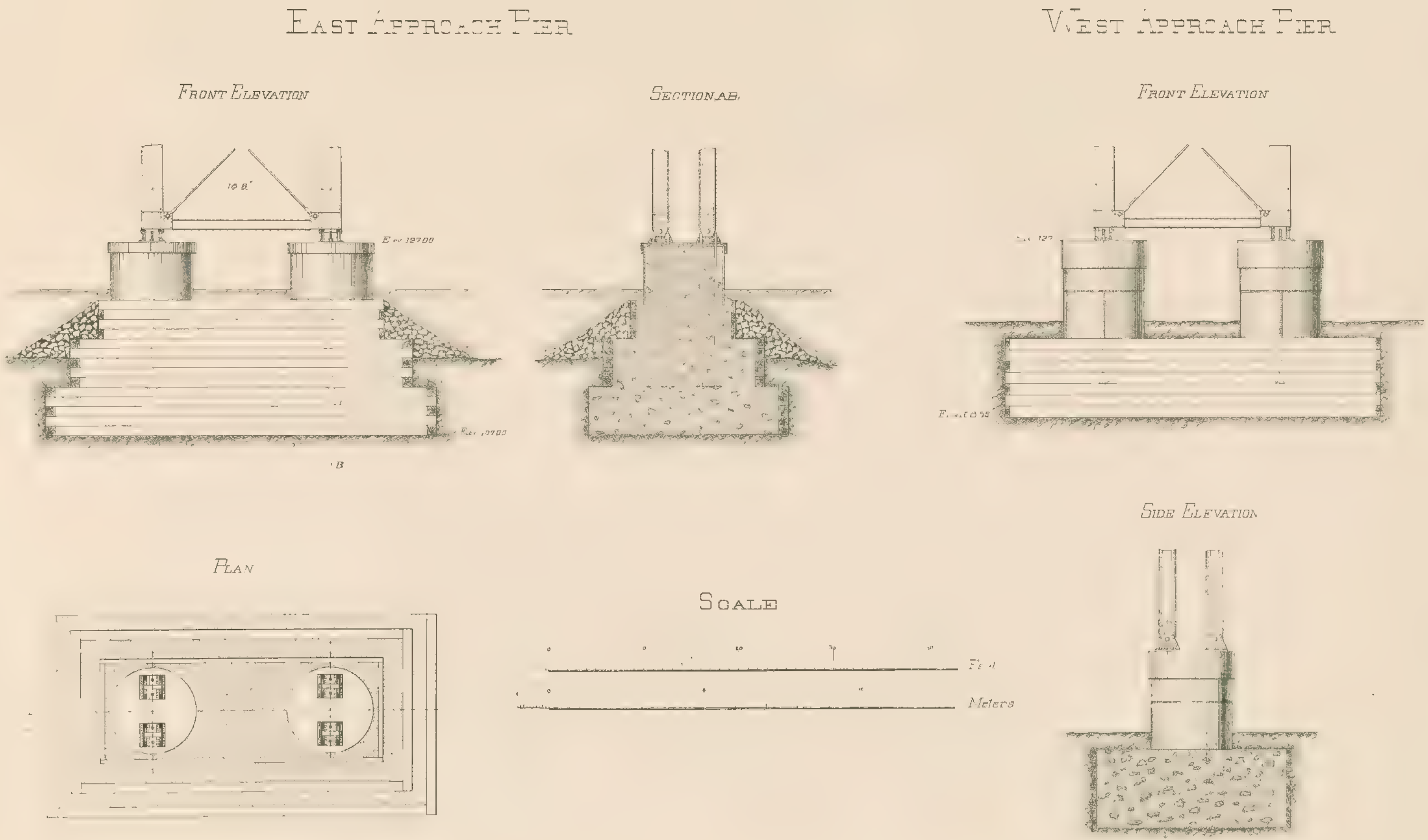


PLATE 11
Front Elevation
Side Elevation
U.P.R.
NEW OMAHA BRIDGE.
WEST ABUTMENT.
Bed Rock
Scale:
Section A.B.
Plan
G. S. Morison
Ch. Engr.

U.P.R.

NEW OMAHA BRIDGE



G. S. Morison
Ch. Eng'r

Plate 13.

U.P.R.

NEW OMAHA BRIDGE

PLAN SHOWING POSITION OF CASTINGS ON PIERS

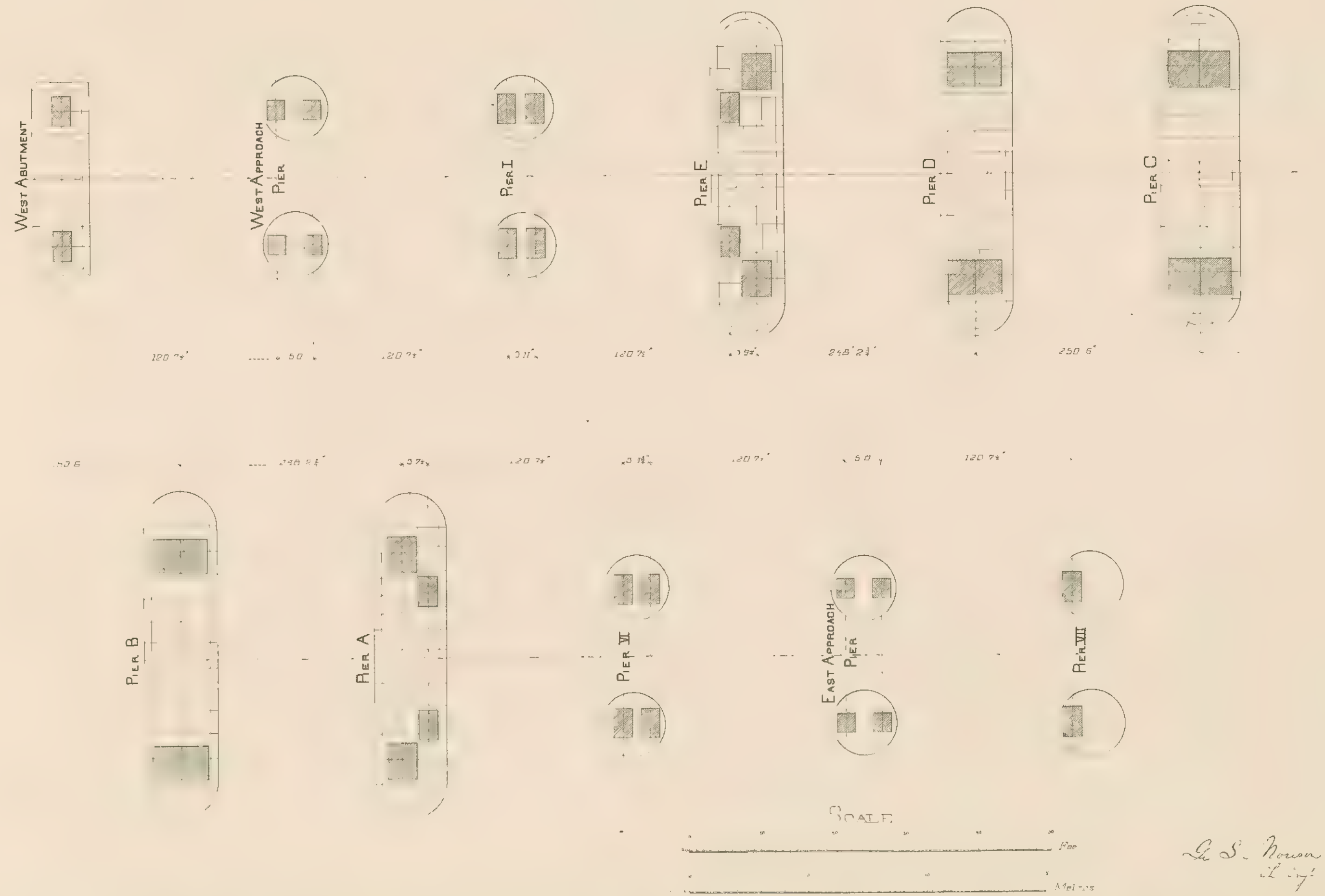


Plate 14.

U.P.R.

NEW OMAHA BRIDGE

RECORD OF WATER STAGE

OF THE

Missouri River

AT OMAHA NEB.

G. S. Morison
Ch. Engr

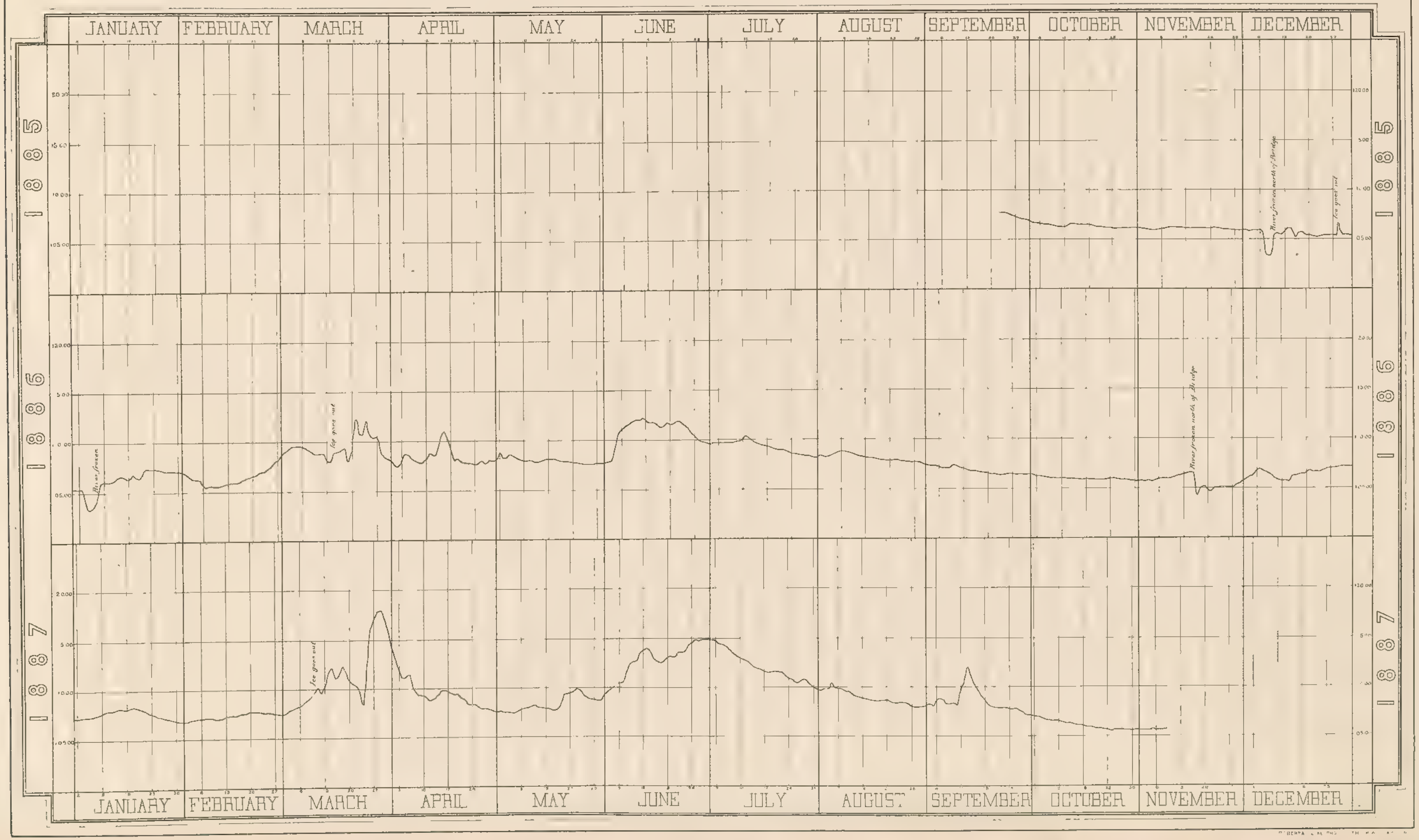
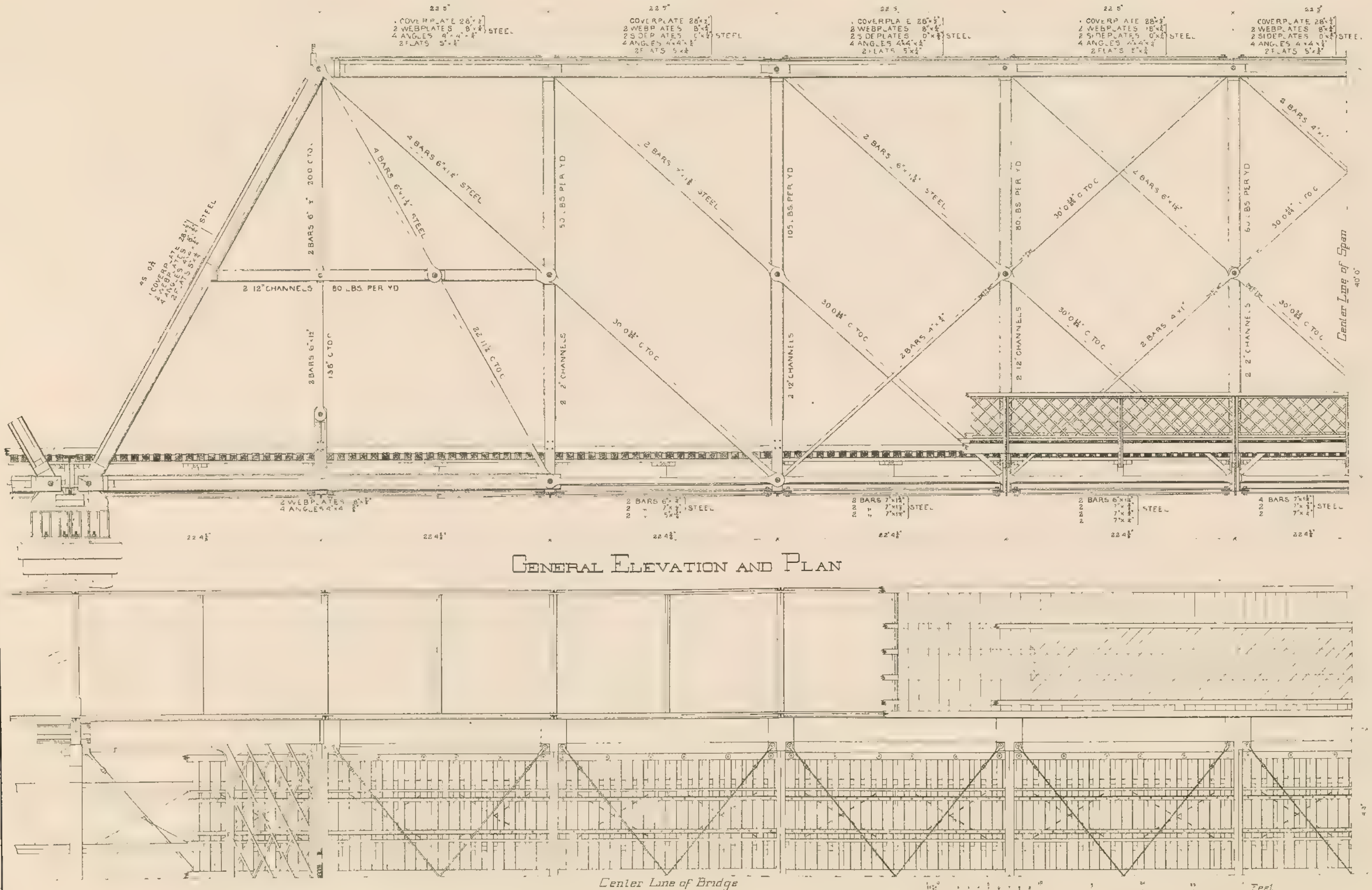


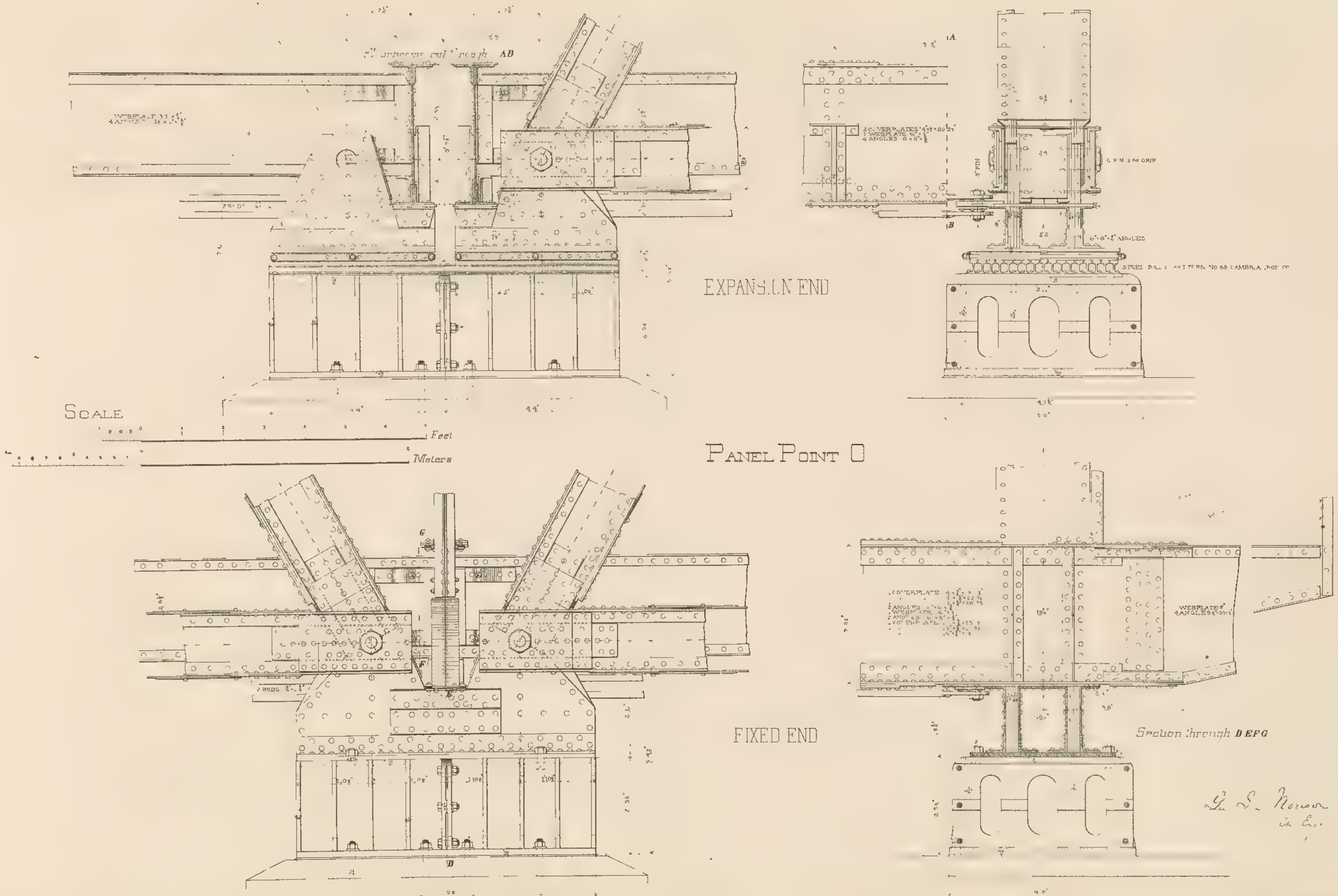
Plate 15.

U.P.R.
NEW OMAHA BRIDGE
THROUGH SPAN 246 FT $2\frac{7}{8}$ IN C. to C. END PINS

G. S. Morison
Ch. Engr

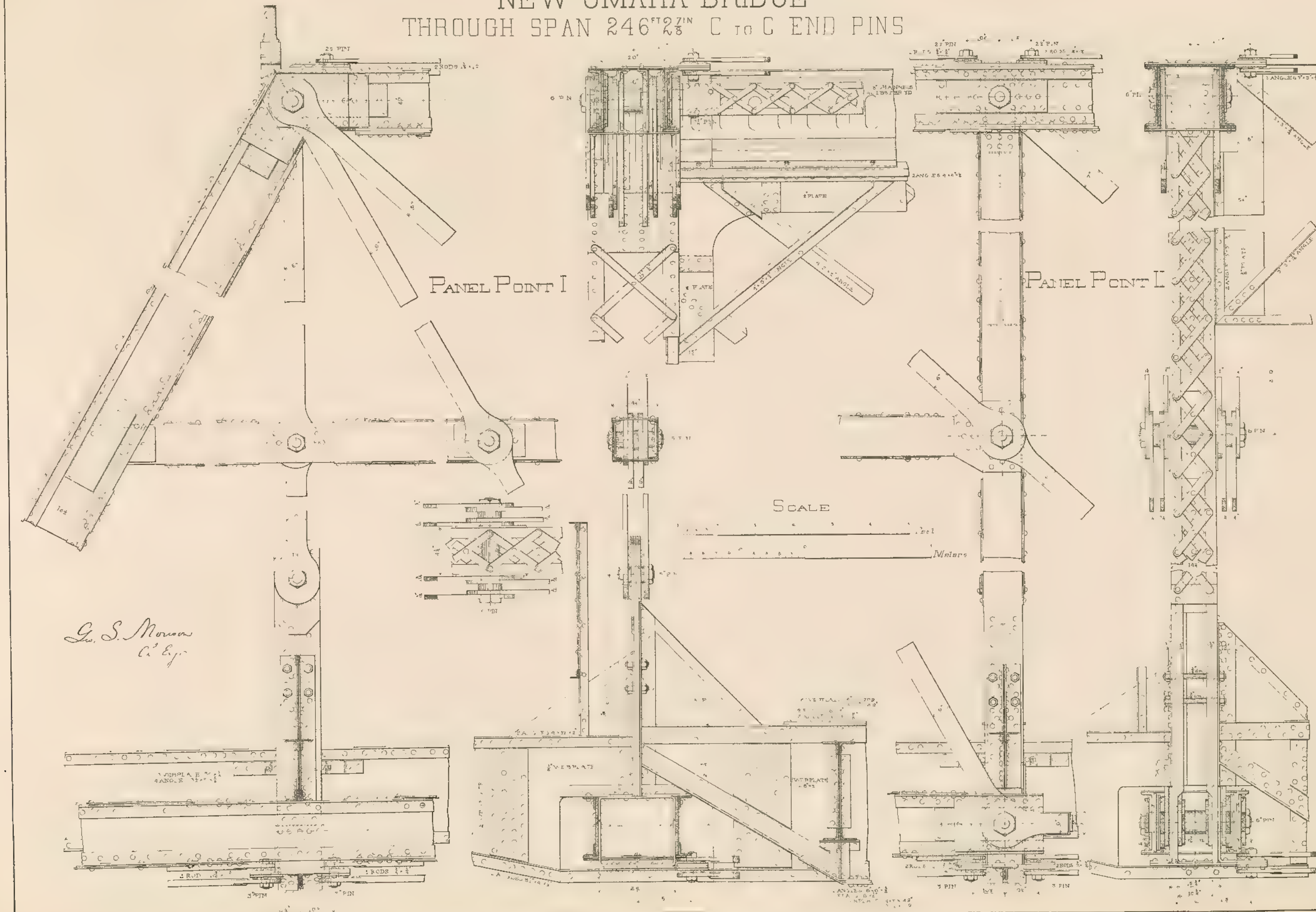


UPR
NEW OMAHA BRIDGE
THROUGH SPAN 246 FT $2\frac{7}{8}$ IN C to C END PINS



ROBERTS WYLIE PHOTO LITH

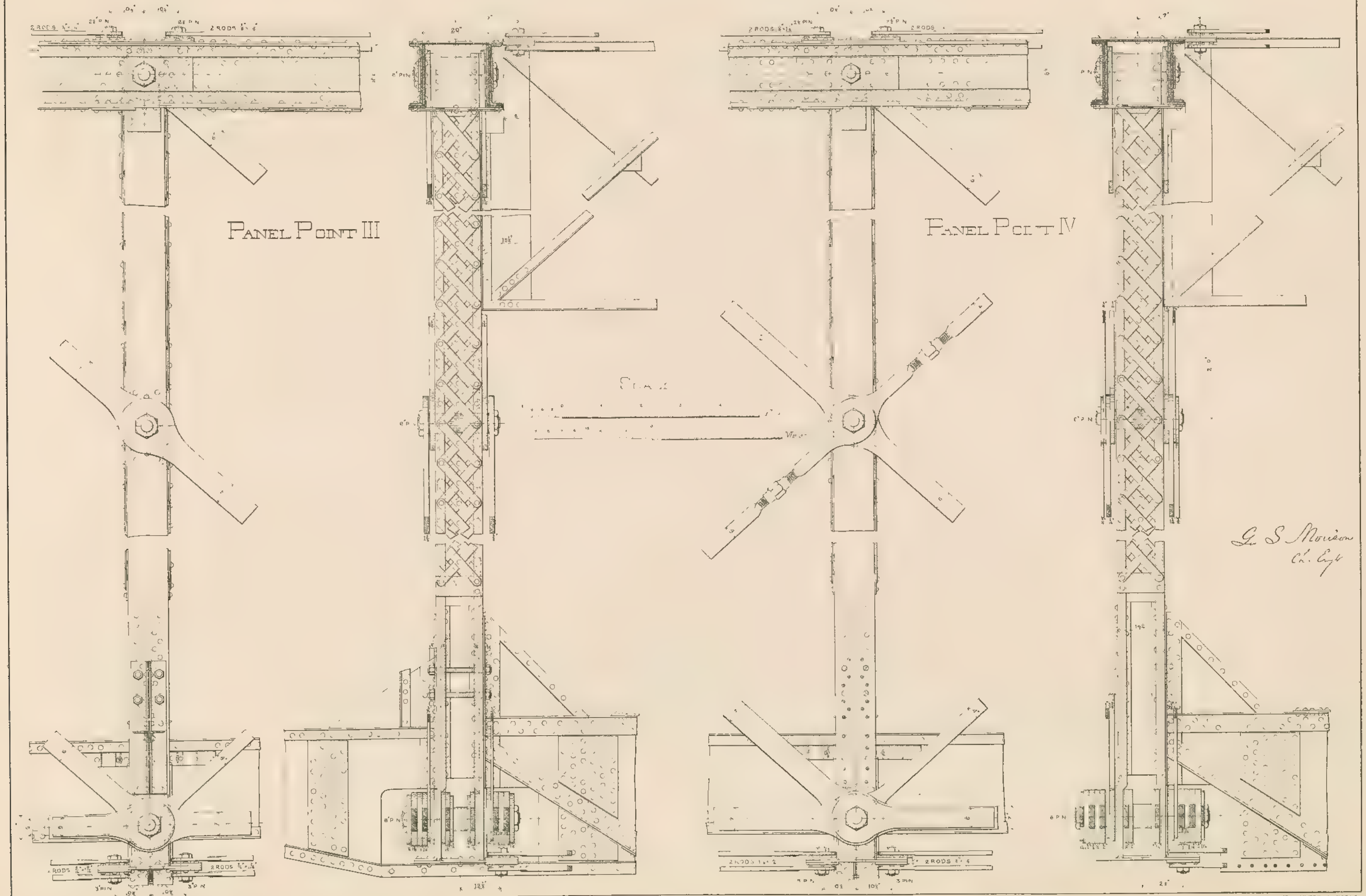
U.P.R.
NEW OMAHA BRIDGE
THROUGH SPAN 246 FT 2 7/8 IN C TO C END PINS



ROBERTS & WELKE PHOTO-LITH. 78 W. ... ST. N.Y.

Plate 18.

UPR.
NEW OMAHA BRIDGE
THROUGH SPAN 246FT 2⅞IN C TO C END PINS



U.P.R.
NEW OMAHA BRIDGE
THROUGH SPAN 246 FT 2 7/8 IN C to C. END PINS

Plate 19

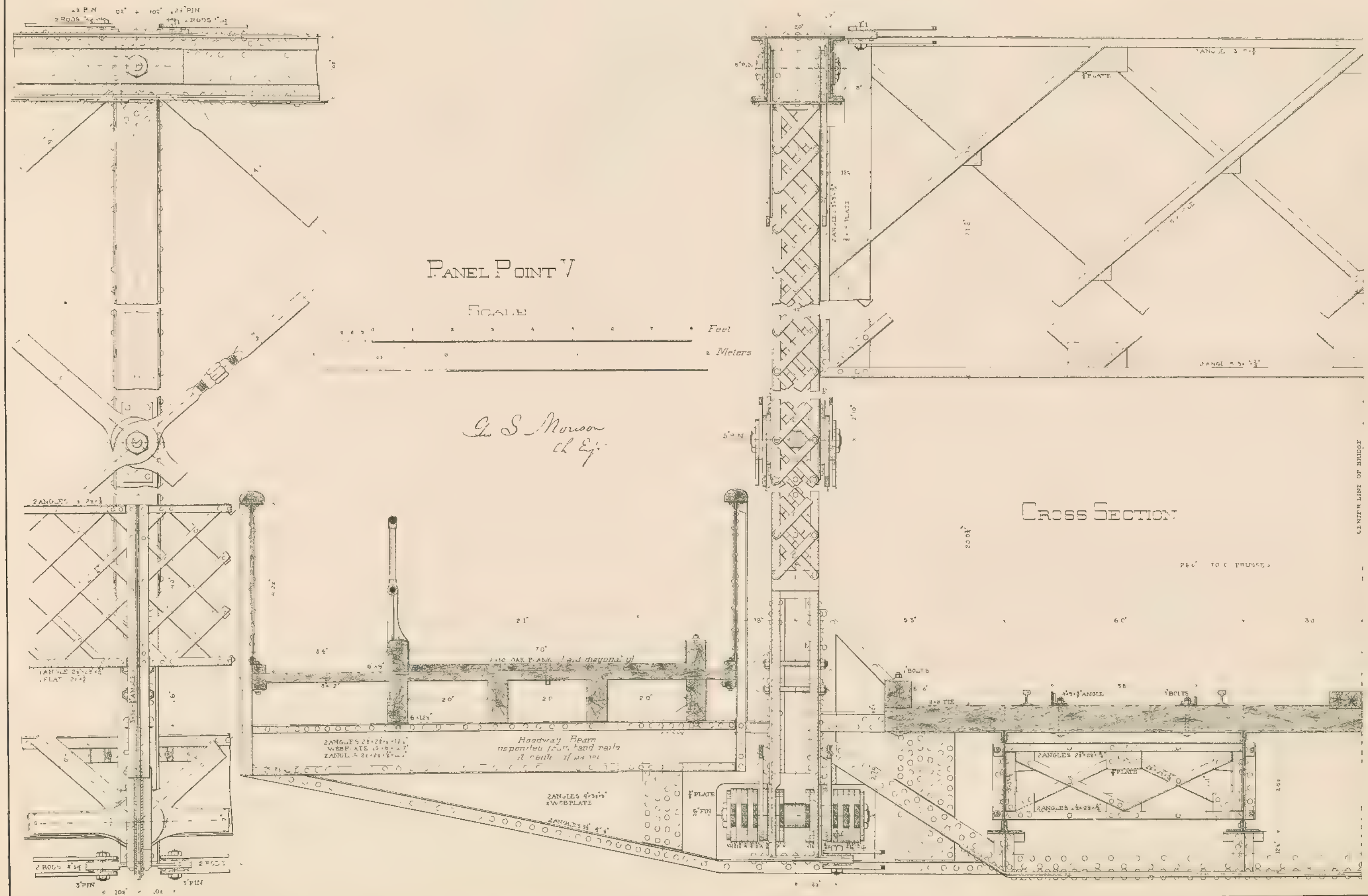
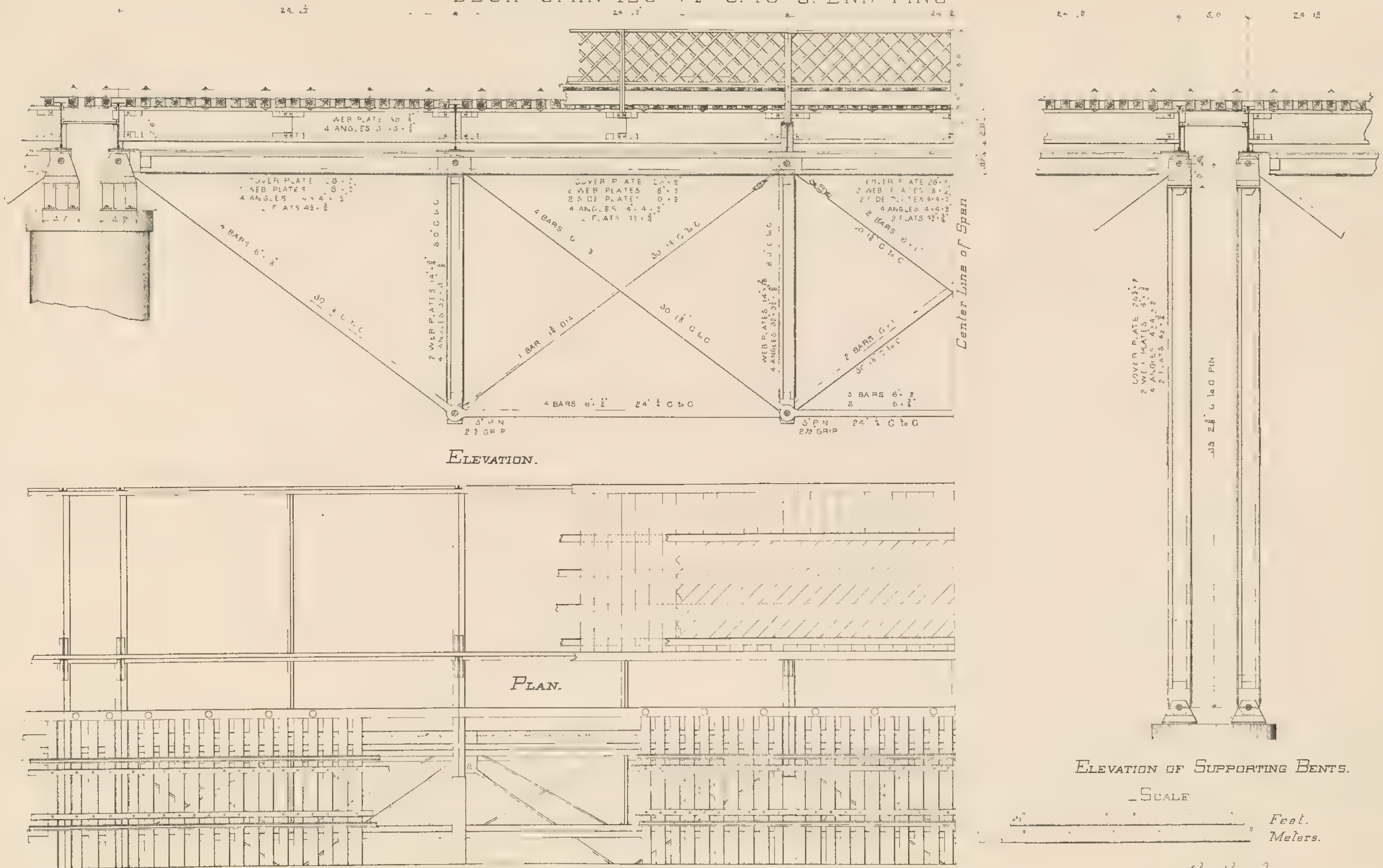


Plate 20.

U.P.R.

NEW OMAHA BRIDGE

DECK SPAN 120 FT 7½ IN C. TO C. END PINS



Elevation.

Plan.

Center Line of Bridge

Elevation of Supporting Bents.

Scale

Feet.

Meters.

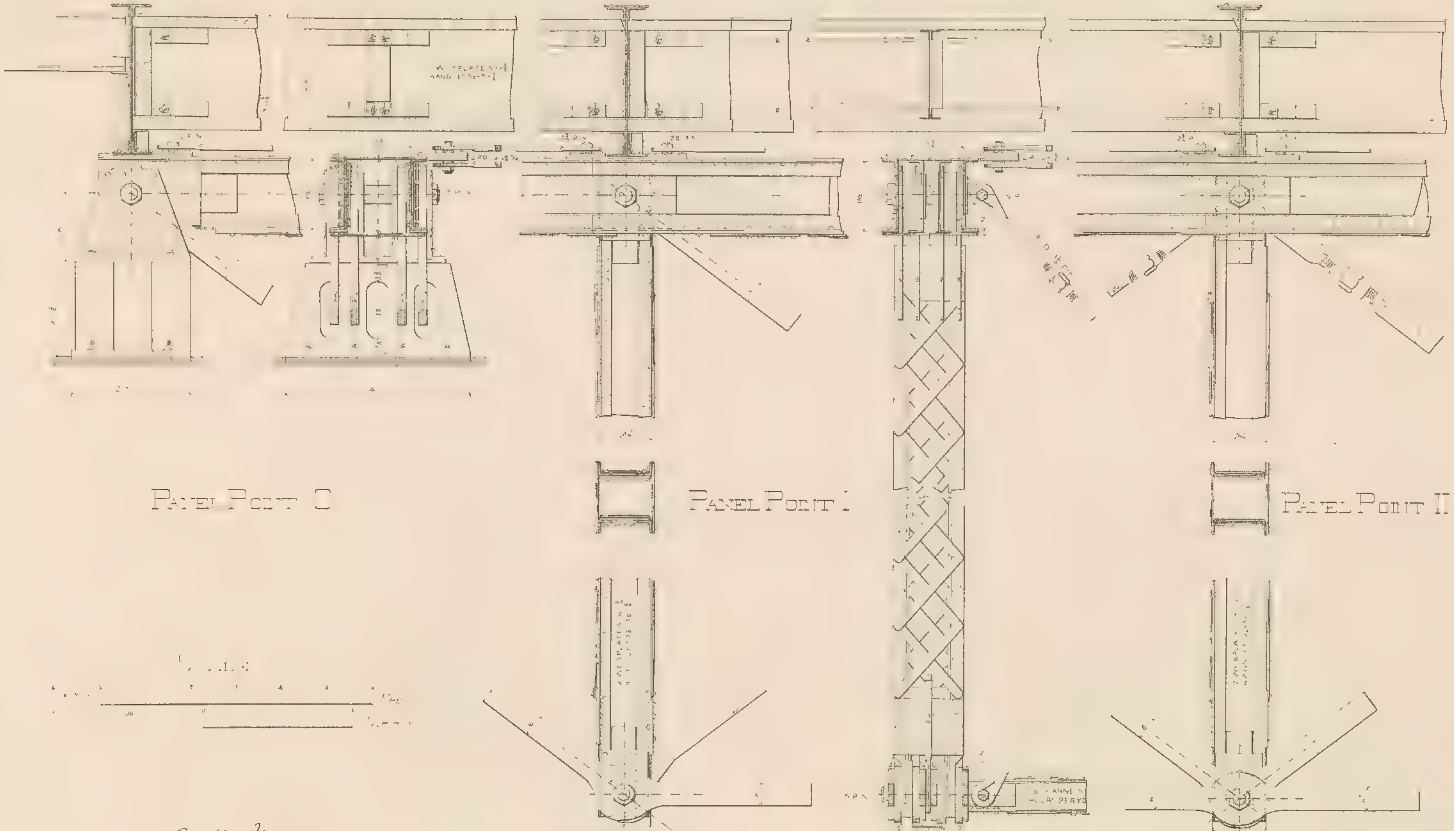
G. S. Morison
Ch. Engr.

Plate 71

U.P.R.

NEW OMAHA BRIDGE

DECK SPAN 130 FT 7½ IN C to C END PINS



Geo. S. Morison
Ch. Engr.

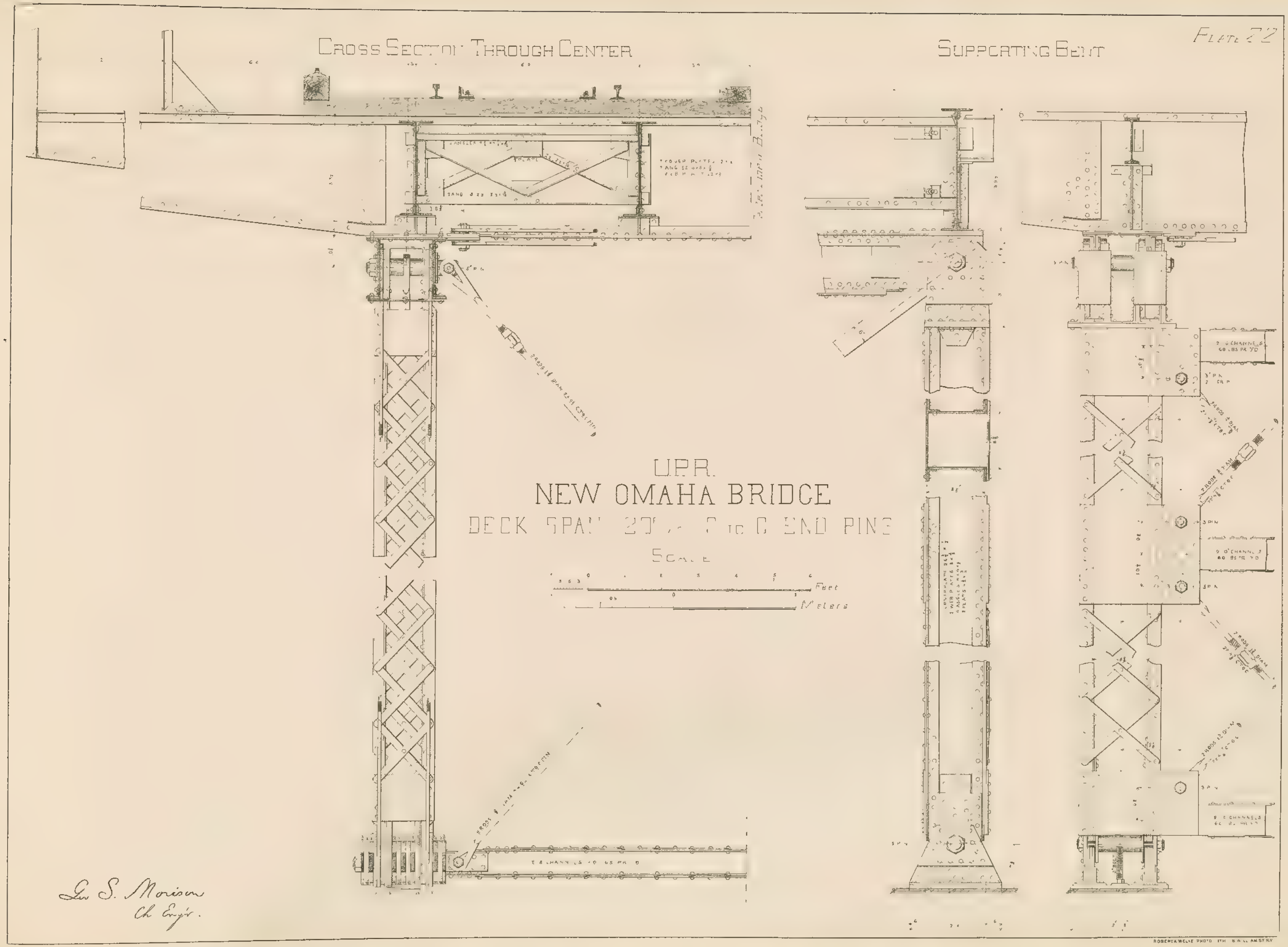


Plate 72
Cross Section Through Center
Supporting Bent
U.P.R.
NEW OMAHA BRIDGE
Scale
Feet
Meters
Geo. S. Morison
Ch. Eng'r.

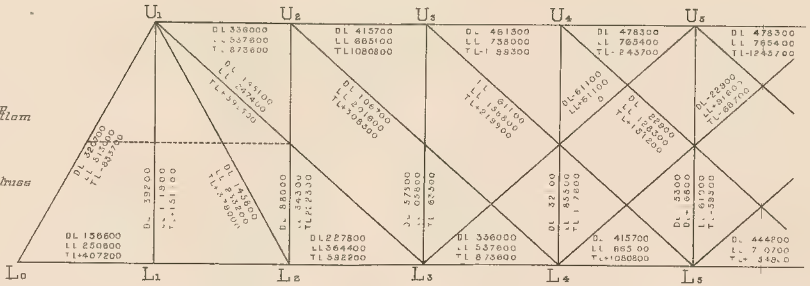
NEW OMAHA BRIDGE

STRAIN SHEET.

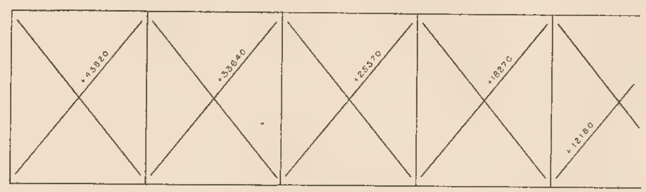
Geo. S. Morison
Ch. Engr.

Assumed Loads in Through Span.

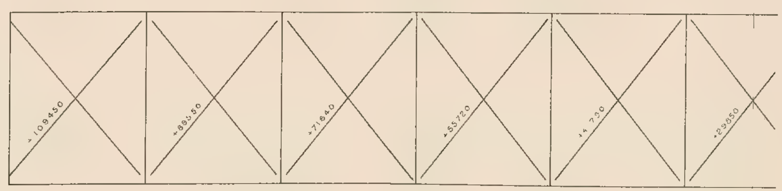
Dead Load 5000# per foot
55963# per panel per truss {16789# at top, 39174# at bottom}
Live Load 8000# per foot 89542# per panel per truss
Total Load 13000# per foot 145505# per panel per truss
Excessive Load 10000# per foot 111927# per panel per truss



TOP LATERAL SYSTEM



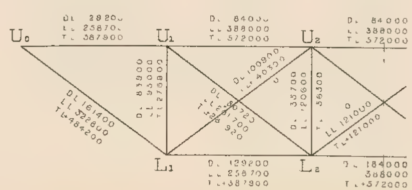
BOTTOM LATERAL SYSTEM.



THROUGH SPAN.

Assumed Loads in Deck Span.

Dead Load 4000# per foot
48[illegible]# per panel per truss {35[illegible]05 at top, 12545# at bottom}
Live Load [illegible]# per foot 96[illegible]# per panel per truss
Total Load 12000# per foot 144750# per panel per truss
Excessive Load [illegible]# per foot [illegible]20625# per panel per truss



DECK SPAN.

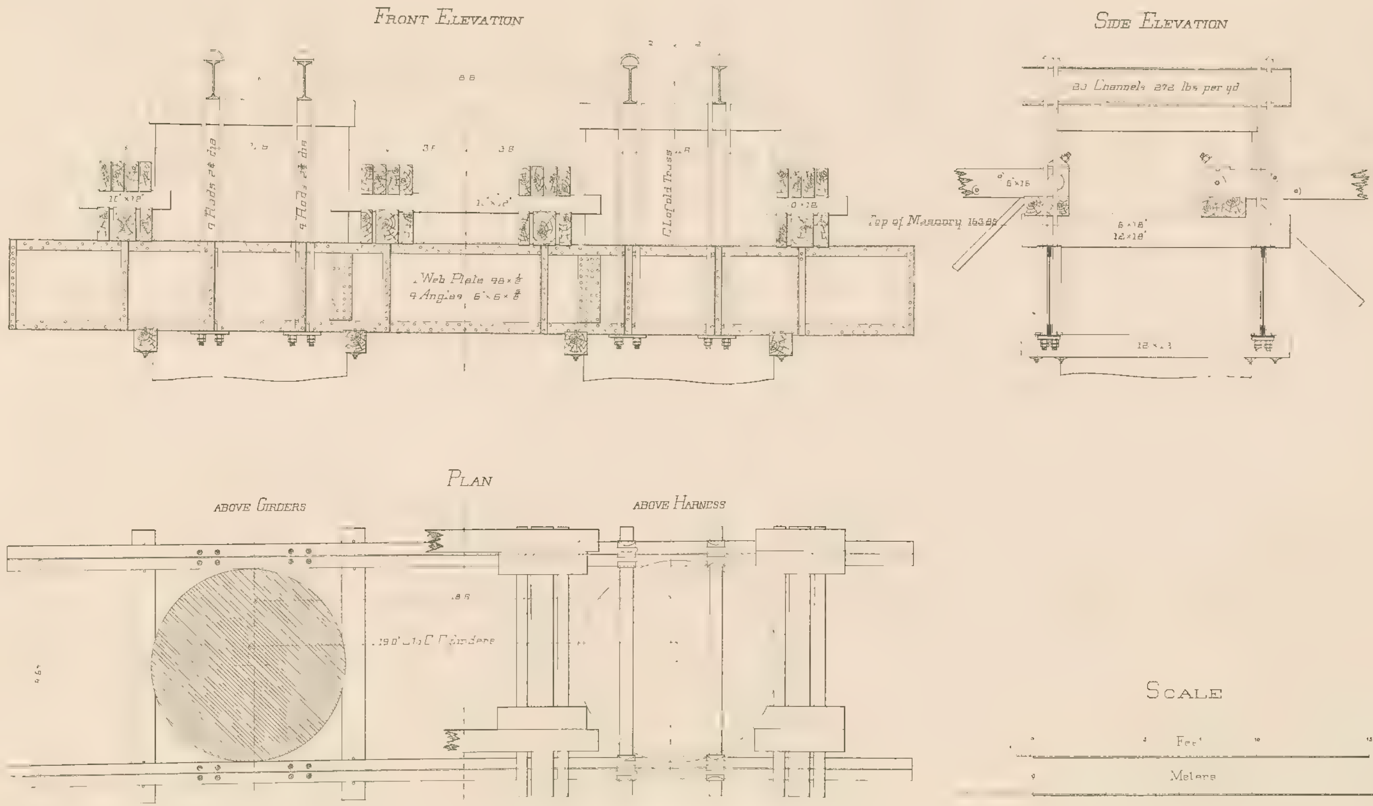
ROBERTS & WE AE PHOTO

Plate 24.

U.P.R.

NEW OMAHA BRIDGE

Harness for Combination Spans



Geo. S. Morison
Ch. Engr.

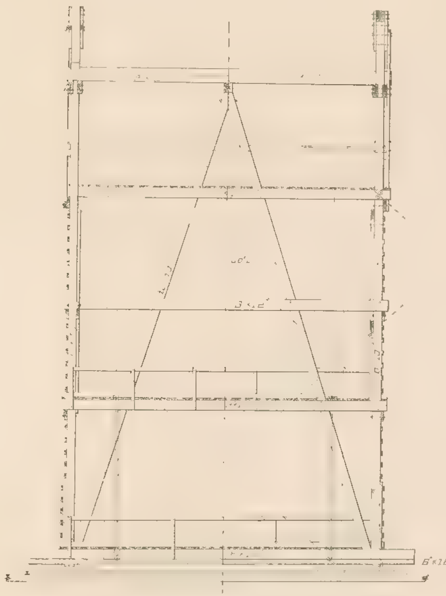
U.P.R.

NEW OMAHA BRIDGE

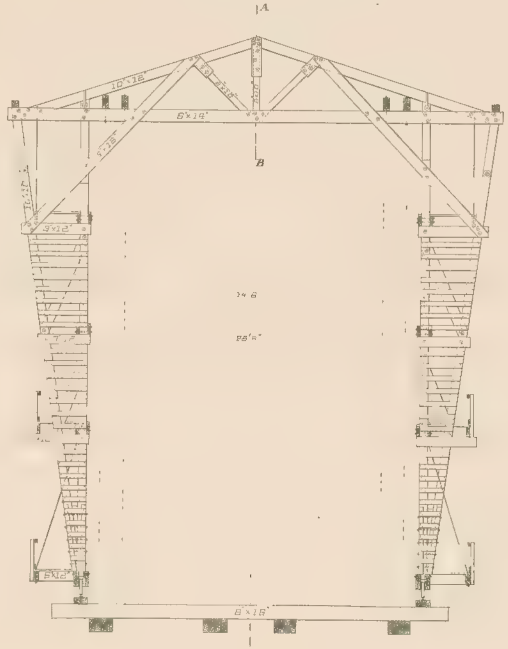
Plate 25

TRAVELER FOR ERECTING MAIN SPANS

Side Elevation *Section (A.B.)*

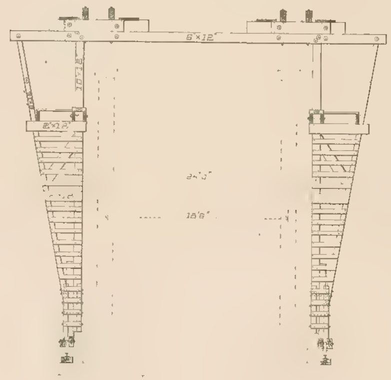


Front Elevation

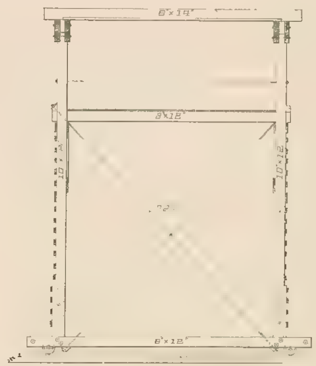


TRAVELER FOR REMOVING OLD SPANS

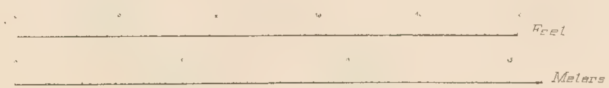
Front Elevation



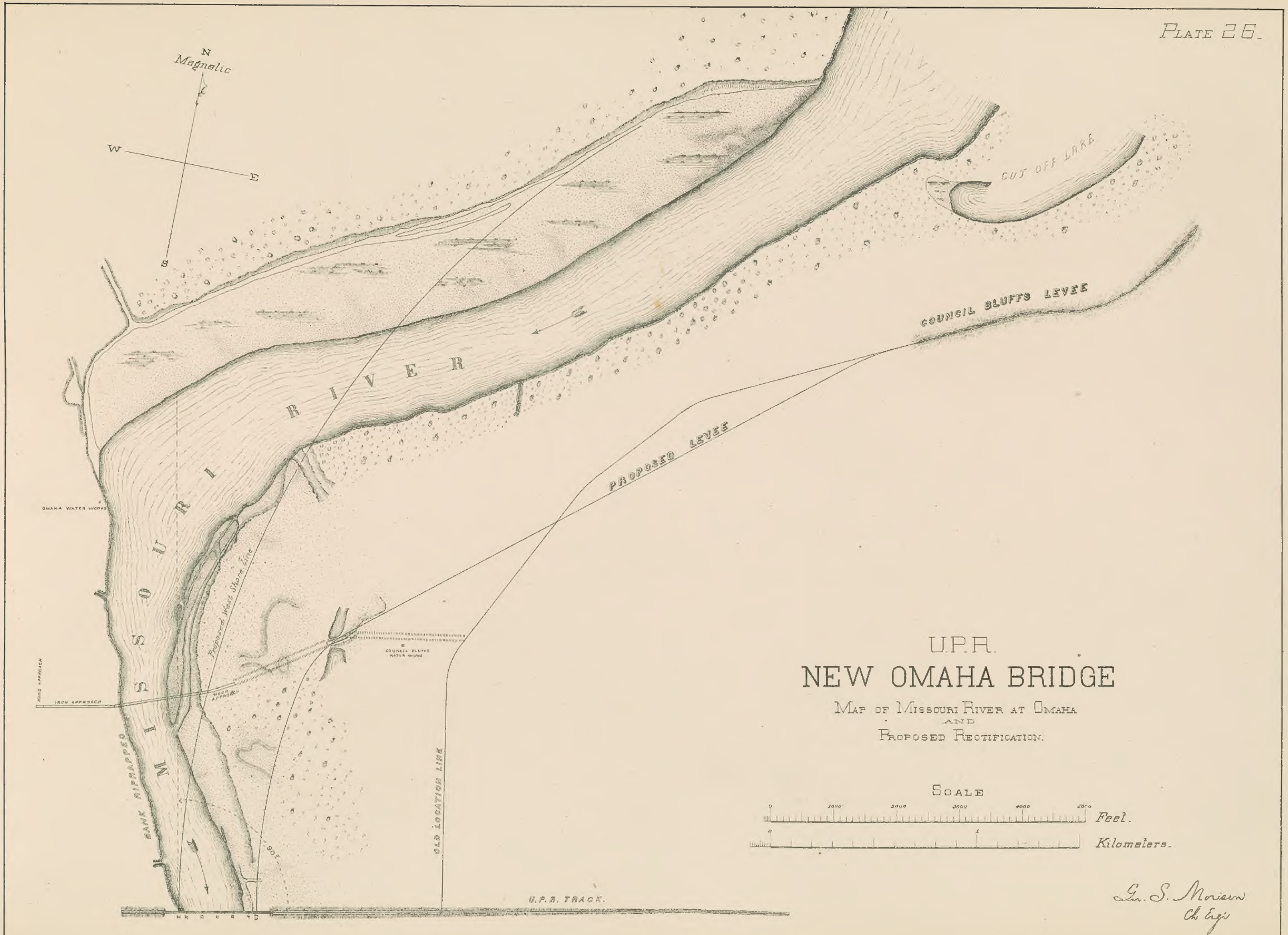
Side Elevation



SCALE



Geo. S. Morison
Ch. Eng'r



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